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Type of fluid-fluid heat exchange: Calculation and structures

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Abstract: A heat exchanger is a device used to exchange the heat between one or more heat carriers. Heat carriers can be separated by plates to prevent mixing or direct contact between heat carriers. These devices are commonly used in heating equipment, refrigerators, air conditioners, power plants, chemical plants, petrochemical plants, refineries, natural gas processing plants, and processors. waste. This article presents the general method for calculating and designing heat exchangers. In addition, some types of heat exchangers such as smooth tube, vortex heat exchanger and plate heat exchanger are also featured in this article.
Keywords: Heat exchanger, smooth tube, vortex heat exchanger, plate heat exchanger

I. INTRODUCTION

A heat exchanger is a device that is made for efficient heat transfer of one part to another. Heat transfermedia can be separated by a solid wall so they do not mix, or they can come in direct contact. Heat exchangers are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, natural gas, Variable and waste water treatment. A common example of a heat exchanger is the heat sink in a car, in which water is used to transfer the heat of the engine to the radiator to the air and cool the engine.

There are two main types of heat exchangers based on flow arrangements. In the parallel heat exchanger, two liquid streams enter the delivery device on the same side, and flow parallel to each other to the other. In the opposite heat exchanger, fluid flow enters the heat exchanger from opposite ends. Reverse line design is the most efficient way in which it can transfer most of the heat from a heat transfer fluid. In the cross-flow heat exchanger, the liquid goes nearly perpendicular to each other through the exchange device. To achieve high performance, the heat exchangers are designed to maximize the surface area of the partition between the two fluid streams while minimizing the flow of fluid through the heat exchanger.

In the heat exchanger technique it is widely used and plays an important role in technological processes such as steam boilers, condensing and evaporating equipment in refrigeration equipment, heat recovery. The structure of the heat exchanger is very diverse in terms of type and depends on technology in production. However, the principle of working heat exchanger can be classified into three main types:

- Out-of contact heat exchanger
- Reflux heat exchanger
- Mixed-type heat exchanger

Technically, each category has different advantages and disadvantages, so depending on the technology of production, choose one or the other. Actually, partition type heat exchangers are very popular so we focus on analyzing and evaluating mainly on this type of equipment. In this type of device the heat carriers move in separate spaces separated by a bulkhead which is the heat transfer surface, eg a liquid moving in a tube and a liquid outside the heat transfer tube to each other through the surface pipe wall

II. EQUATION OF HEAT TRANSFER

The thermal calculation of the vessel heat exchanger is to determine the surface area of the heat transfer surface to transfer a given amount of heat or heat transfer surface to determine the parameters of the equipment (selecting the equipment structure). The basic equation for heat calculation:

$$Q = K.F.\Delta t \quad (1)$$

$$Q = G_1.C_{p1}.(t_1' - t_1'') = G_2.C_{p2}.(t_2'' - t_2') \quad (2)$$

Where:
Q: heat transfer (W)
K: heat transfer coefficient ($W/m^2.K$)
F: surface area of heat transfer (m^2)
Δt: average temperature difference between hot and cold substance (^oC)
G: working fluid mass flow through the heat transfer surface (kg/h)
C_p: specific heat of iso-volume of hot and cold substance (J/kg.K)

t: temperature of hot substance and refrigerant (^oC)
Symbol (1) is hot, (2) is cold; 'Is the substance that comes in,' 'is the substance that comes out.
With the problem of calculating the area of heat transfer F, we must go to determine k and Δt. Also, with the problem of F and K, for certain flow velocities, Q and output temperature must be determined.

2.1. Heat Transfer coefficient K
+ For the flat walls:

$$K = \frac{1}{\frac{1}{\alpha_1} + \sum \frac{\delta_i}{\lambda_i} + \frac{1}{\alpha_2}} \quad (3)$$

α: convective heat transfer coefficient of heat and cold (is the amount of heat transferred in a unit of time, through an area unit with temperature difference of the thermal carriers is 1^oC)
δ, λ: thickness and thermal conductivity of flat wall of i (W/m.K)
+ For the pillar walls:

$$K = \frac{1}{\frac{1}{\alpha_1 . d_1} + \sum \frac{1}{2\lambda_i} \ln\left(\frac{d_{i+1}}{d_i}\right) + \frac{1}{\alpha_2 . d_2}} \quad (4)$$

Inside:
α: convective heat transfer coefficient of hot substance and cold substance
$d_{1,2}$: The innermost and outer diameter of the wall
d_i, λ_i: Inner diameter and thermal conductivity of the i th layer

The large heat transfer surface, the condition of the heat transfer in the various parts are different, then the parts are divided into averages:

$$K = \frac{\sum K_i . F_i}{\sum F_i} \quad (5)$$

When performing different heat transfer on both sides of the wall, but in case of increased surface heat transfer by tendons or wings, K is equal to:

$$K = \frac{1}{\frac{1}{\alpha_1} + \sum \frac{\delta_i}{\lambda_i} + \frac{1}{\alpha_2} \frac{F_1}{F_2}} \quad (6)$$

Where:
$F_{1,2}$: Heat transfer area of heat, cold
The ribbed side radiator not only depends on the speed and thermal conductivity, but also on the shape and orientation of the ribs. The calculation of the heat transfer coefficient is determined by empirical formulas to give the optimum geometrical parameters to suit the specific requirements.

Exothermic processes include: heat conduction, convection and radiation cannot calculate the specific heat of transmission in one form one should be characterized by a parameter α:

$$\alpha = f(t, p, \omega, \nu, C_p, \lambda, \gamma, L \text{ và } \Phi)$$

General form:

$$\alpha = A . Re^m . Pr^n . Gr^x . \left(\frac{Pr}{P_1}\right)^y . \left(\frac{\lambda}{L}\right) \quad (7)$$

2.2. Mean temperature difference t
+ Same direction

$$\Delta t = \frac{(t_1' - t_2') - (t_1'' - t_2'')}{2{,}3 \lg \frac{t_1' - t_2''}{t_1'' - t_2'}} \quad (8)$$

+ Inverse direction

$$\Delta t = \frac{(t_1'-t_2'') - (t_1''-t_2')}{2{,}3\lg\dfrac{t_1'-t_2''}{t_1''-t_2'}} \qquad (9)$$

+ Mix-direction (same direction and inverse direction)

$$\Delta t = \xi \frac{(t_1'-t_2'') - (t_1''-t_2')}{2{,}3\lg\dfrac{t_1'-t_2''}{t_1''-t_2'}} \qquad (10)$$

Correction factor ξ is found in the table following to the P and R, and

$$P = \frac{t_2''-t_2'}{t_1'-t_2'} = \frac{\delta t_2}{\delta t_{max}} \qquad R = \frac{t_1'-t_1''}{t_2''-t_2'} = \frac{\delta t_1}{\delta t_2} \qquad (11)$$

if $\dfrac{t_1'-t_1''}{t_2'-t_2''} < 2$ then $\Delta t = \dfrac{t_1'+t_2'}{2} - \dfrac{t_2''-t_1''}{2}$

III. FLUID- FLUID HEAT EXCHANGER

3.1. Smooth round tube

Working fluid is usually fresh water, lubricant and fuel, the pressure is from 0.005 to 300 bar. Good heat transfer fluid due to its specific heat, density and thermal conductivity should reduce the size of the heat exchanger. Heat exchanger includes Non-partitioned and bulkheads; U-shaped tube; Tube in tube. Some smooth tubes are shown in Figure 1.

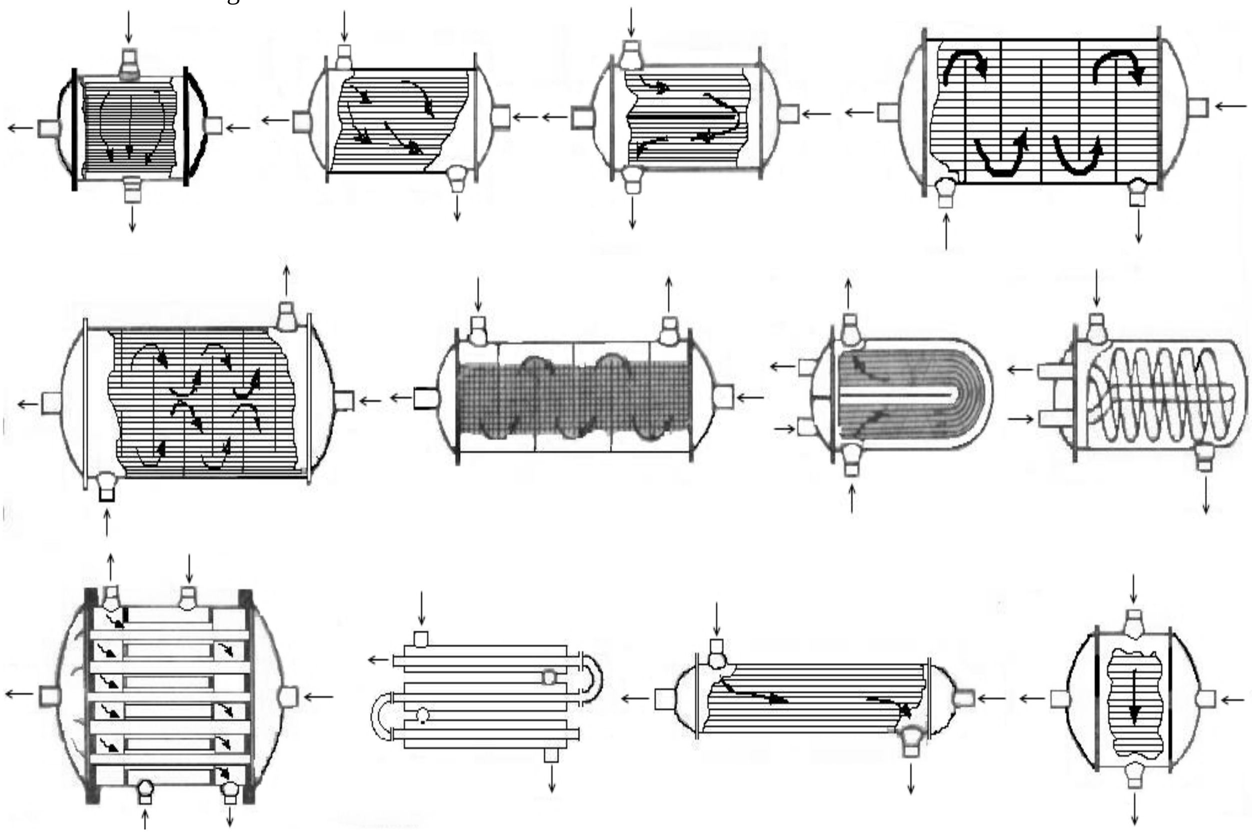


Figure 1. Some kind of smooth tube heat exchanger

The fluid-to-liquid heat exchanger is usually made of circular cylinders, which are internally bundles capable of conducting good heat. Usually people give poor heat transfer, less dirt off the tube. When two liquids have the same heat transfer coefficient, the flow is small and the two both produce poor heat transfer, the heat exchanger design extends. If there is a large heating coefficient, shorten and increase the number of tubes. And if one side of the liquid has a low heat exchanger, it flows outwards in a perpendicular direction and flows back and forth several times through the bulkhead. The fluid direction in the heat exchangers (HE) has three main types: vertical, horizontal and mixed. In which horizontal flow is the best heat transfer efficiency, compact structure but great resistance.

Anti-Expansion Structure: During operation, the details of the HE exposed to high temperature cause thermal expansion. Therefore, the structure of HE should be able to resist heat expansion. Often people use the following measures: The expansion is compensated by bending the front tube or extruding the extruded shell structure (Figure 2(a, b)); The structure has a mobile screen. Suitable when low pressure high temperature change (Figure 2c); Less tube number: Suitable for non-scale liquids (Figure 2(d, e)).

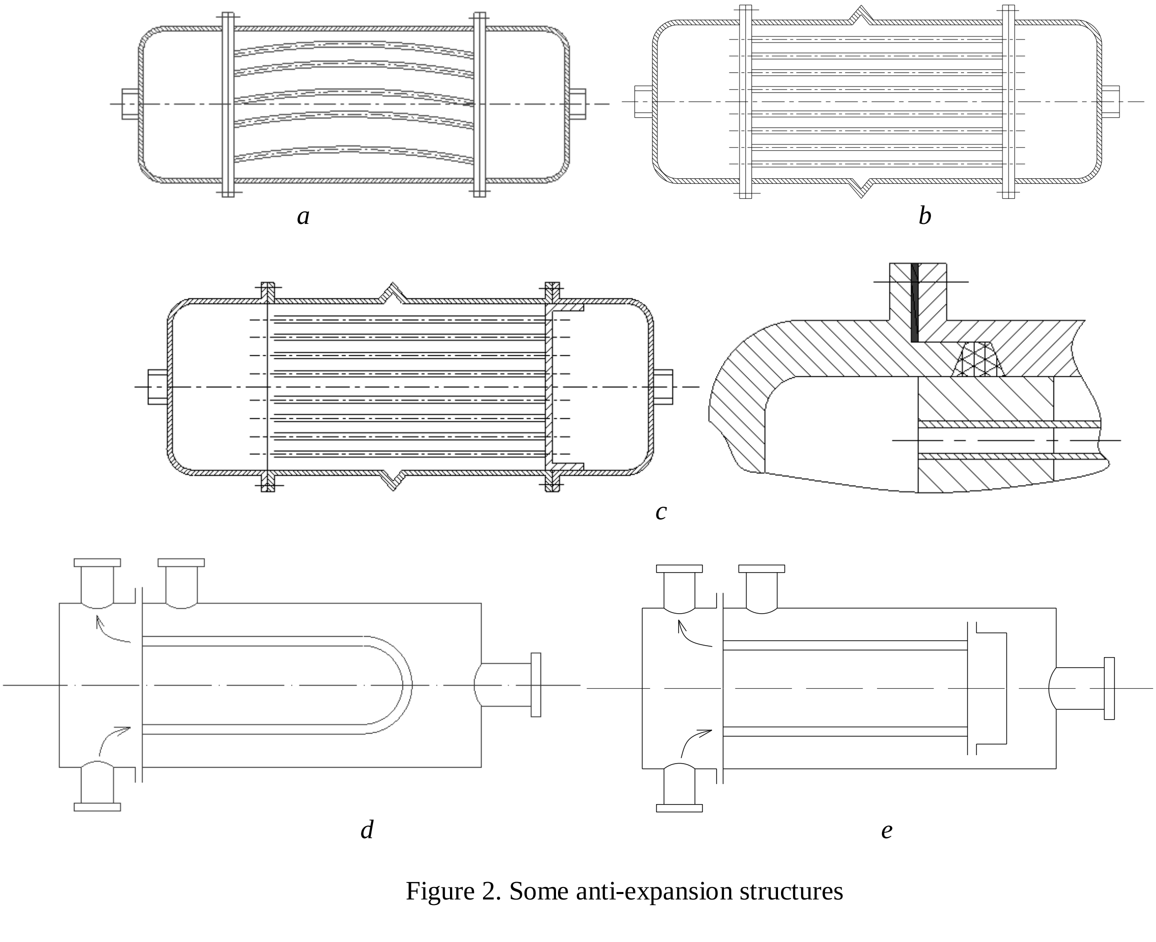
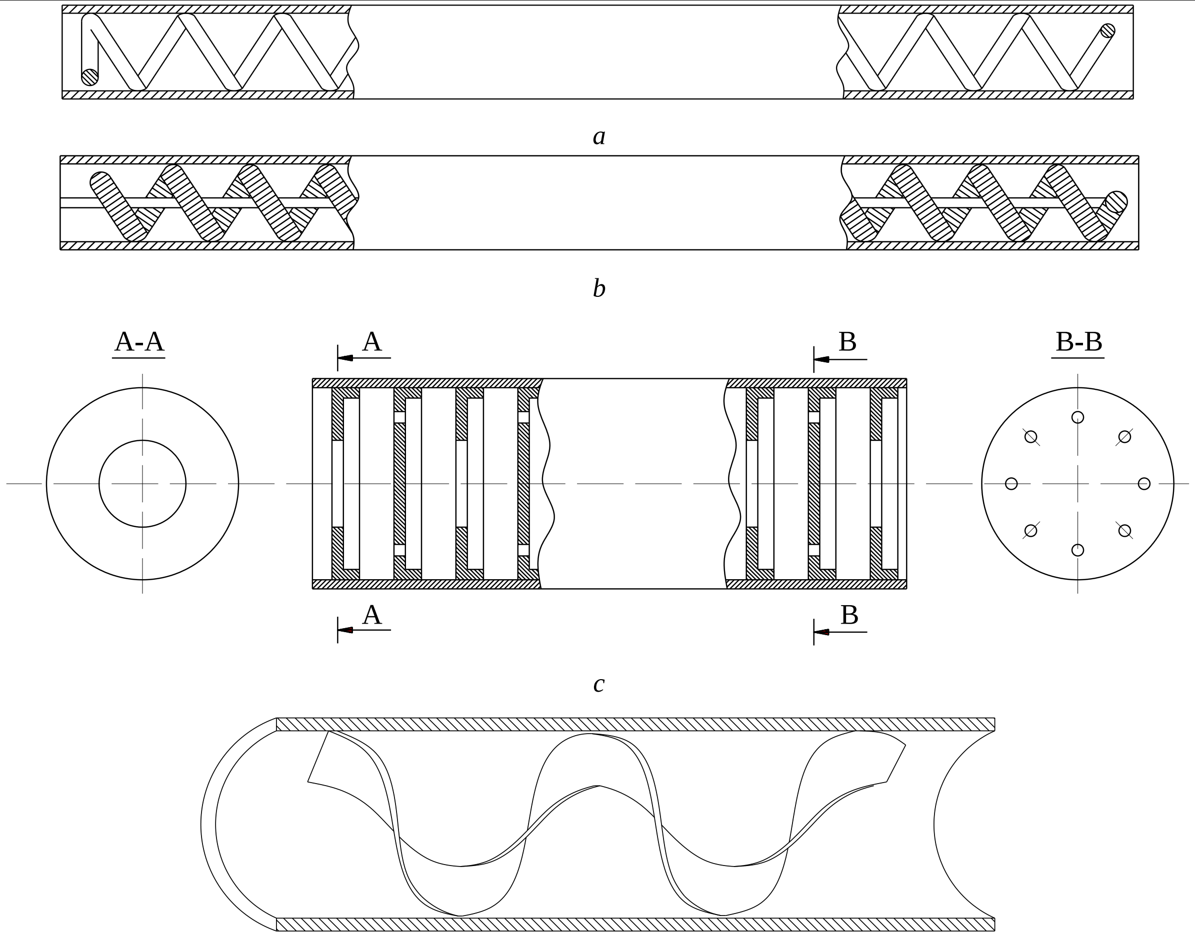


Figure 2. Some anti-expansion structures

3.2. Round tube with vortex device

Swirl heat exchangers operate on the principle of upstream heat transfer. Two heat exchangers are arranged in opposite directions in the spiral channels. In it, a fluid moves from the center of the device to the outside while another fluid moves from the outside to the center of the device and then exits the device in the lid or bottom of the device depending on the specific structure.

Swirl-type heat exchangers are self-cleaning. With a smooth, curved channel structure, the tendency for the scale to deposit on the heat exchanger plate is very low. Any position on the conduit channel if localized localization occurs results in reduced channel cross section and hence the velocity of the fluorescence across this section increases. As the flow rate increases, it will scrape off the sediment on the channel wall. Self-cleaning capability reduces the operating costs of equipment, especially when the equipment is installed horizontally. Fluids give better heat at higher velocities or turbulent conditions, thus increasing the heat transfer of the liquid into the tube by making the flow in the tube tangle. Usually they use the following methods: simple wires (Figure 3.a); complex wires (Figure 3.b); wires with a strip of metal (Figure 3.c); circular discs (Figure 3.d).



d

Figure 3. Some vortex-round tube structures

The choice of vortex construction depends on the permissible size of the equipment and the loss of pressure as well as on the fabrication and mining conditions. It should choose the structure (d) will be less pressure loss for FO. Vortex parts welded by tin with tube wall to increase the contact will give good heat transfer efficiency. The design of the swirl heat exchanger achieves the ideal conditions for a heat exchange process by achieving a uniformly uniform flow characteristic for all fluids involved in the heat exchanger in the equipment. Design and manufacture of conventional swirl heat exchangers are relatively simple, the heat exchangers are wrapped from two metal sheets around a core to form two spiraling channels around the center of the device. Drainage channels are usually sealed to avoid mixing of the two heat exchangers. The operating mode of the device is optimized by changing the width of the conduit. The width of the conduit can range from 5mm to 30mm. Typically, this heat exchanger is designed with a cap sealed by a collar, thanks to which the lid can be easily opened for cleaning and maintenance of the equipment.

3.3. Plate heat exchanger

Made from plates, the surface molded into grooves or molded into various forms. Depending on the heat transfer, select the appropriate material (brass, bronze, stainless steel, etc.). Liquid chambers are separated by slabs and pads (sealing the joints between the plates and separating the hot and cold ones). Plate Heat Exchanger (PHE) is an industrial cooler, made up of thin metal plates sealed with rubber gaskets (or sealed with alloy welds).) Helps prevent the two streams of hot and cold fluids. Two hot and cold streams flow interspersed between the plates, which are crushed to create turbulent flow for the two fluids to achieve maximum heat transfer yield. Because each plate has a large surface area, it creates a large heat exchanger surface between the media. Compared to traditional chandelier heat exchanger with the same capacity, a PHE unit will have better heat transfer performance. Moreover, with PHE sanitation, maintenance and maintenance process is also easier. The advantages of this type are compact structure, good heat transfer by bending in channels with a height of 3 ÷ 5mm; the heat exchange surface can be changed by changing plate number, plate spacing and flow chart;

quick disassembly. However, the disadvantages of this type are limit pressure and sealed number of sealing much. The structure of this type is shown in Figure 4.

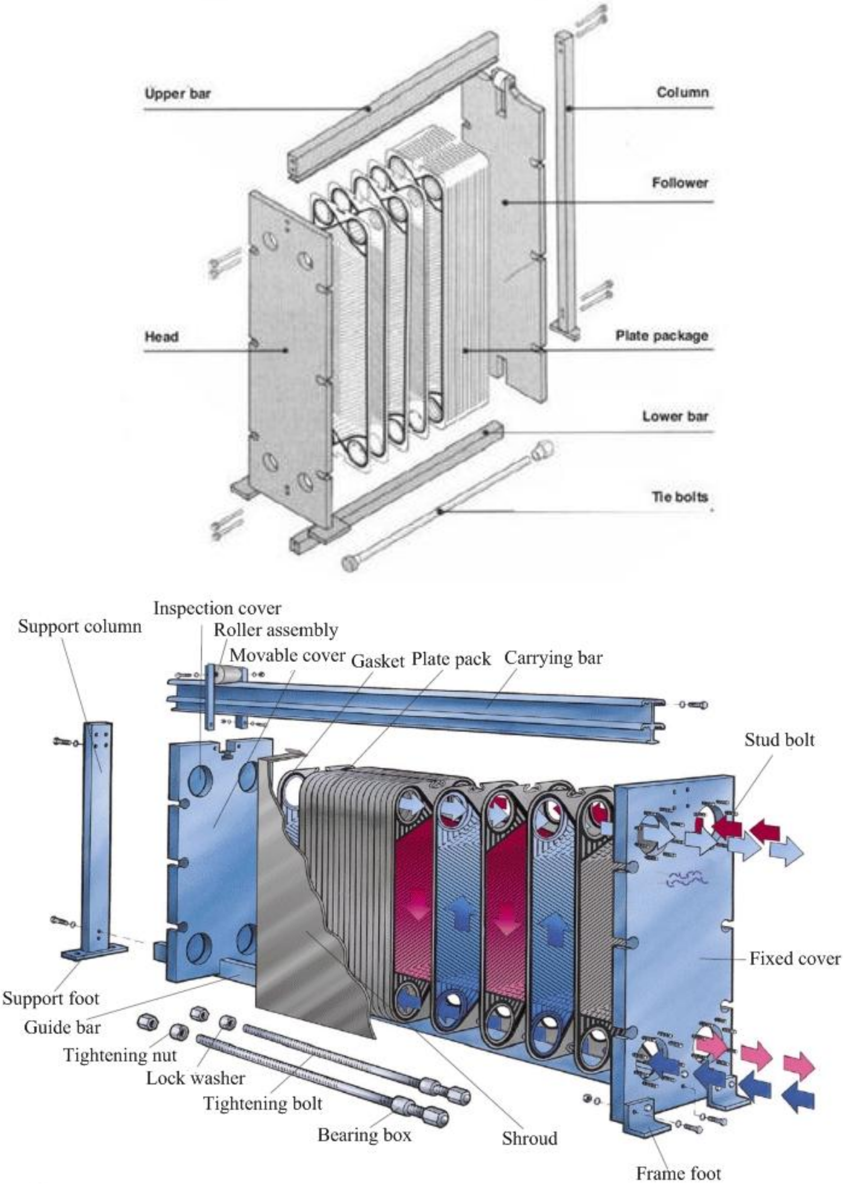


Figure 4. The structure of plate heat exchanger

IV. CONCLUSION

The article presents the general calculation method for heat exchangers. Thereby, the article introduced some types of heat exchangers for two liquid-liquid working fluid. The results of this article contribute to the calculation and design of specific heat exchangers for different uses. In the next study, the authors will present calculation and design methods for other types of heat exchangers.

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