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ANALYSIS OF MATHEMATICAL CALCULATIONS OF HEAT EXCHANGE DEVICES

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Abstract: In the national economy, the process of processing products under the influence of heat is widely used, so heat exchange devices are used in many production enterprises, depending on the type of products. Heat exchange devices are used in the industry for the following purposes: maintaining the process temperature at a given level; heating a cold product or cooling a hot product; condensing solutions; vapor condensation and others. These processes are carried out in separate heat exchange devices or in the technological device itself.

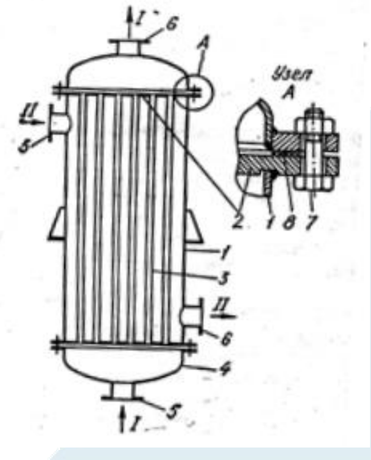
Key words: Processing products, temperature, heat exchange, heat transferring, friction coefficient, shell-and-tube heat exchanger.

Introduction. Heat exchange devices are generally divided into two: heat exchange devices themselves and reactors. In heat exchange devices, the heat exchange process is considered the main one, and the heat exchange is an auxiliary process. According to the methods of heat transfer, heat exchange devices are divided into the following:

1) surface heat exchange devices, in which the surface separates heat from one environment to another.

2) mixing heat exchangers, in which working environments are mixed. Surface heat exchangers are widely used for heating and cooling liquids and gases in all industries.

According to the constructive structure, surface heat exchange devices are divided into tube, coil, plate, spiral, sheath and special heat exchange devices. Heat exchangers are divided into heaters, evaporators, coolers and condensers according to their use and type of heat exchange. Depending on the type of working medium, there are gas, steam-gas, gas-liquid, steam-liquid, liquid heat exchangers.



One of the most widely used heat exchangers is shell and tube heat exchangers. Devices of this type are very widespread. Such heaters consist of a set of pipes located inside the shell, and the ends of the pipes are fastened to the grids. The cover on the upper and lower parts of the device is attached to the pipe network using a flange. The figure below shows a one-way shell-and-tube heat exchanger. In this case, the heated gas or liquid enters through one tube with a valve on the cover and leaves through that tube.

1 figure. One-way shell-and-tube heat exchanger.

1-shell, 2-pipes mesh, 3-pipes, 4-cap, 6-pipes for entering and exiting heat agents, 7-bolt, 8-gasket.

Often, in this type of heaters, the media being heated and giving off heat move in opposite directions. The heating agent is always fed into the pipes from the top of the heater. The direction of these media corresponds to the direction in the heater, because their densities change as the temperature increases and decreases in the heated and shell-tube.

Calculation of heat exchangers. When designing heat exchangers, various calculations are first performed for them. The calculation consists of three parts; a) heat calculation; b) constructive calculation; c) hydraulic calculation.

The main purpose of the heat calculation of the apparatus is to find the required heat exchange surface f. To determine f, the consumption of heat transfer agents, their initial and final temperatures are given.

As a result of such a heat calculation, the following is determined: Average temperature difference and average temperatures of the working environment; 2) Amount of heat and consumption of working bodies; 3) Heat transfer coefficient; 4) Heating surface.

Heat calculation is carried out in continuous connection with structural and hydraulic calculation. Let's consider the heat calculation of a tube heater that works continuously and is adapted to vapor-liquid environments. the following initial information must be provided:

Amount of heated solution g, kg/s.

The concentration of the solution S, %.

The initial and final temperatures of the solution are t_i, t_f

Type of heater - vertical, horizontal pipes, number of paths.

Pressure p or temperature t of heating steam,

The inner and outer diameters of the steel pipes are d_i and d_o

The length of the pipes is l, m.

Movement speed of the solution ω, m/s.

Coefficient of use of the heating surface φ.

The calculation is carried out in the following order

1. Determining the temperature conditions of the heater. According to the saturated vapor pressure p, the saturation temperature t_s is found in special manuals. maximum temperature difference at the start of heating:

$$\Delta t_{max} = t_s - t_i$$

The minimum difference in ambient temperatures at the end of heating:

$$\Delta t_{min} = t_s - t_f$$

The value of temperature difference Δt_{max} and Δt_{min} is determined as follows,

If $\frac{\Delta t_{max}}{\Delta t_{min}} > 2$

$$\Delta t_{average} = \frac{\Delta t_{max} - \Delta t_{min}}{2.3lg\frac{\Delta t_{max}}{\Delta t_{min}}}$$

If $\frac{\Delta t_{max}}{\Delta t_{min}} > 2$

$$\Delta t_{average} = \frac{\Delta t_{max} + \Delta t_{min}}{2}$$

The average temperature of the heated environment:

$$t = t_s - \Delta t_{average}$$

2. Determining the amount of heat, steam and water consumption. The amount of heat used to heat the liquid is found from the following equation:

$$Q = nGC(t_f - t_i), \text{ J.}$$

Here, n = 2.14...1.05 is the heat loss coefficient, G is liquid consumption, kg/c; C - heat capacity, $j\ /\ (kg.k)$; t_f is the final temperature of the liquid, $℃$; t_i is the initial temperature of the liquid, $℃$;

If a gas or liquid is being cooled, the amount of coolant is determined as follows:

$$G' = \frac{G \cdot C(t_f - t_i)}{C'(t_f' - t_i')}, \text{ kg/s.}$$

where C' is the heat capacity of the coolant; t'_f - the final temperature of the coolant; t'_i - the initial temperature of the coolant.

3. Hydraulic calculation of heat exchangers. The main purpose of hydraulic calculations is to determine the pressure required to overcome friction and local resistance in heat exchangers, and to find the total effort and power required to transfer the working medium through the device. In order to determine the hydraulic resistance of the device, it is necessary to know the resistance of the media moving between the pipes and in the pipes. The resistance of the moving medium between the pipes (that is, between the pipes and the apparatus wall) is determined as follows:

$$\Delta P = \xi \frac{\rho \omega^2}{2}$$

where ω - the speed of the medium moving between the pipes: ρ - the density of the medium at an average temperature: ξ - the coefficient of resistance between the pipes, the amount of which depends on the length of the pipe: for pipes with a length of 6 m ξ = 350...450; ξ = 0.5-1.5 for pipes with a length of 1...3 m.

The hydraulic resistance of the pipes is equal to the sum of the pressure ΔP_l lost to overcome the frictional resistances in the pipe and the pressure lost to overcome the local resistances ΔP_{lr}:

$$\Delta P = \Delta P_l + \Delta P_{lr}$$

In straight tubes, the pressure loss to overcome friction is found by the following equation:

$$\Delta P_l = \lambda \frac{1}{d_e} \cdot \frac{\omega^2 \rho}{2}, \quad {}^{n}/_{m^2}$$

where λ is the friction coefficient; d_e - the equivalent diameter of the channels: ω - the velocity of the working medium in the channels; ρ - the density of the medium; l is the length of the channels.

Conclusion. Counter flow heat exchangers use flows in the opposite direction of each other. Shell and tube, and double pipes heat exchangers are examples of common exchangers using counter flow configurations. The best design for shell and tube and double-pipe exchanger is counter flow configuration, and the heat transfer between the fluid is the maximum. In counter flow, the efficiency is higher than the parallel, and temperature in the cooling fluid outlet can exceed the warmer fluid inlet temperature. Above, in the article, we analyzed mathematical calculations and mathematical models for several parameters of shell-and-tube heat exchangers, these are: determining the temperature conditions of the heater; determining the amount of heat, steam and water consumption and hydraulic calculation of heat exchangers. Similarly, there are mathematical analyzes of other parameters of heat exchangers, such analyzes allow to analyze the process depending on the properties of mutual heat exchangers in technological processes.

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