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RESULTS OF IMPROVING THE CONSTRUCTION OF THE PLATE HEAT EXCHANGE

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Abstract: The article examines modern methods of intensifying heat exchange in plate heat exchangers by changing the geometry of channels. The effectiveness of corrugated, chevron, and zigzag structures in reducing flow resistance and increasing the heat transfer coefficient has been substantiated. The peculiarities of the influence of the slope angle of the plate relief on the turbulence of the flow and the formation of stagnant zones are analyzed. Recommendations for choosing geometry are given, taking into account operating conditions in the gas processing industry.

Keywords: plate heat exchanger, heat exchange, turbulence, channel geometry, heat transfer coefficient.

Introduction. Gas processing plants play a key role in ensuring the efficient and environmentally safe use of hydrocarbon raw materials. In their technological schemes, plate heat exchangers are widely used, which are distinguished by their compactness, high heat output, and the ability to quickly disassemble for maintenance. However, in the context of processing natural gas and gas condensates containing mechanical impurities, sulfurous compounds, and condensate fractions, heat exchangers often encounter problems of contamination and overgrowth of heat-transmitting surfaces [1-3].

These processes significantly reduce the thermal efficiency of the equipment, increase energy costs, and cause unscheduled downtime for cleaning and repair. In this regard, the task of increasing the reliability, resistance to pollution, and overall efficiency of plate heat exchangers is relevant both from a technological and economic point of view. Improving the design, optimizing the channel geometry, and applying modern anti-corrosion and anti-friction coatings not only extends the service life of the apparatus but also increases the energy efficiency of the entire production process [4-7].

Modern research shows that changing the geometric configuration of the channels of plate heat exchangers contributes to a significant increase in the heat transfer coefficient - by an average of 15-30% compared to traditional designs. The main mechanism for increasing efficiency is the intensification of turbulent flows due to the specially profiled surface of the plates [8].

The development and implementation of technical solutions aimed at improving plate heat exchangers for gas processing facilities is an important direction contributing to the reduction of operating costs, increasing the stability of equipment, and increasing the overall productivity of the plant [9].

Methods and materials. The analysis was conducted based on a comparison of various types of channels - smooth, corrugated, chevron (30°, 60°), and zigzag. Calculated heat transfer formulas (heat flow equation, dependencies for Nu, Re, Pr) and empirical data from publications were used.

Modeling results and data from industrial facilities are also presented. The heat capacity was calculated at $A = 10\ m^2$, $\Delta T = 20\ °C$, $\alpha_1 = 1800\ W/(m^2 \cdot K)$, $\alpha_2 = 3000\ W/(m^2 \cdot K)$, $\delta = 0.0006\ m$, $\lambda = 15\ W/(m \cdot K)$.

Calculation:

$$1/k = 1/1800 + 0{,}0006/15 + 1/3000 \approx 0{,}0005561$$

$$k \approx 1798\ W/(m^2 \cdot K)$$

$$Q = k \times A \times \Delta T = 1798 \times 10 \times 20 = 35960\ W$$

Results and discussions. One of the key parameters influencing heat exchange intensity is the angle of inclination of channels formed by the relief of the plates. The angle affects both the hydrodynamic resistance and the formation of secondary flows within the channels. Most common ranges:

- 30-40° - provide moderate turbulence and low hydraulic resistance. Suitable for clean environments with limited energy consumption.
- 45-60° - create a strong turbulence, intensifying heat exchange, but require more powerful pumping equipment.

Table 1. Dependence of the heat transfer coefficient on the channel relief angle

Angle of relief inclination	**Heat transfer coefficient α, $W/(m^2 \cdot K)$**
30°	2500
40°	2700
50°	2950
60°	3200

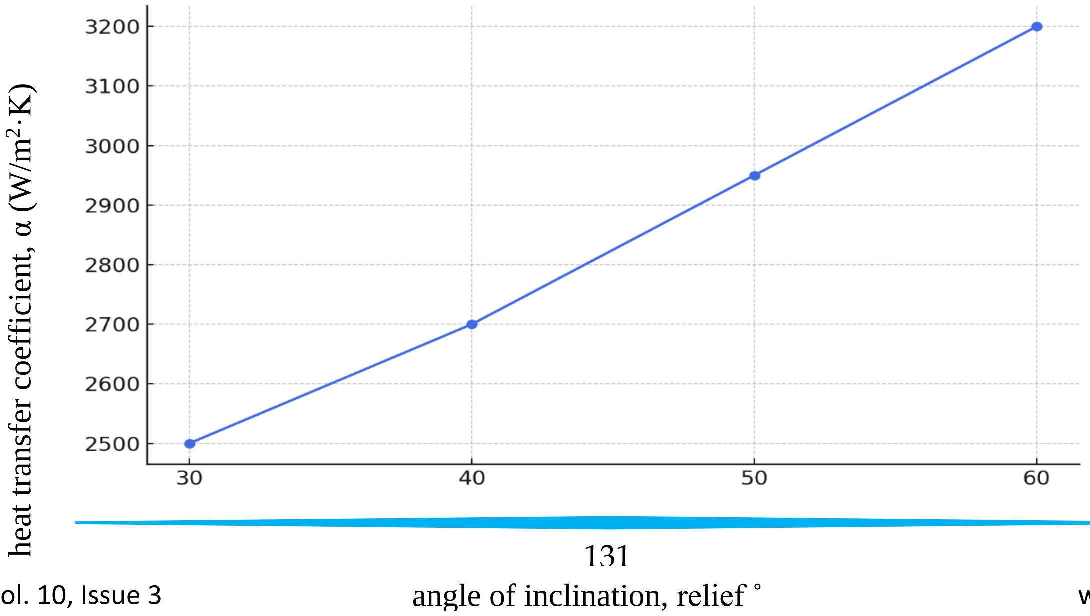

Figure 1. Influence of the terrain slope angle on the heat transfer coefficient

Combining plates with different angles of inclination (for example, alternating between 30° and 60°) allows for flexible adjustment of heat transfer and resistance, adapting the heat exchanger to variable operating modes.

One of the main factors influencing the efficiency of heat exchange in plate heat exchangers is the geometry of the heat exchange surface. In particular, the angle of inclination of the relief has a significant influence on the heat transfer coefficient.

Studies have shown that increasing the terrain slope angle from 30° to 60° leads to a progressive increase in the heat transfer coefficient: from 2500 to 3200 W/ (m^2·K). This is due to the increased turbulence of the heat carrier flow, caused by steeper elevations of the relief, which contributes to the improvement of heat exchange between the surface and the working medium.

The graph showing this trend is shown in the figure: at 30° - α = 2500 W/ (m^2·K); at 40° - α = 2700 W/ (m^2·K); at 50° - α = 2950 W/ (m^2·K); at 60° - α = 3200 W/ (m^2·K).

Thus, optimizing the terrain slope angle can be considered an effective method for increasing the thermal productivity of heat exchangers, especially under conditions of limited heat exchange area.

In addition, the elevation and shape of the relief, as well as the width of the flow between the plates, play an important role. It has been experimentally proven that increasing the groove depth while maintaining the angle of inclination increases the turbulence level, however, excessive increase leads to increased resistance and material wear.

For gas condensate and amine-containing flows, it is recommended to use channels with a 45-60° angle, made of stainless steel or titanium, with protective coatings against aggressive components. For intermediate cooling of gas with high dust content - plate heat exchangers with zigzag channels and vibration-resistant fastening are used.

Table 2. Comparison of pressure differences for different channel geometries

Channel type	Pressure drop, kPa
Smooth	18
Smooth chevron (30°)	22
Acute chevron (60°)	28
Zigzag	26

Table 2 shows the pressure drop (in kPa) that occurs when a heat carrier passes through channels of various types in a plate heat exchanger. The pressure drop depends on the geometry of the channels: the more pronounced the turbulence of the flow, the higher the resistance to the movement of the medium.

A smooth channel provides the lowest hydraulic resistance, but also the lowest turbulence of the flow, which means limited heat exchange. Smooth chevron (30°) creates moderate resistance (22 kPa) and provides improved mixing. The sharp chevron (60°) forms the most pronounced turbulence, providing better heat exchange, but is accompanied by the greatest pressure drop - 28 kPa. The zigzag channel occupies an intermediate position: it creates significant resistance (26 kPa) due to multiple changes in flow direction.

Thus, when designing heat exchangers, it is necessary to find the optimal balance between the heat transfer efficiency and the permissible pressure losses.

The results show that the use of chevron and zigzag channels allows for a significant increase in the thermal characteristics of plate heat exchangers. At the same time, the angle of inclination of 60° provides the maximum heat transfer coefficient, however, it requires the strengthening of the pumping equipment. The decrease in canal pollution also has a positive impact on the cleaning intervals and the service life of the equipment. Industrial cases confirm the effectiveness of the transition to improved geometry.

Conclusion. Modification of the channel geometry of plate heat exchangers is an effective direction for increasing the thermal and operational efficiency of equipment, especially in conditions of polluted environments characteristic of gas processing plants. The implementation of chevron and zigzag plates with the optimal inclination angle allows for significant improvement in heat transfer and resistance to contamination. An additional advantage of these structures is the reduction of the risk of stagnant zones and deposits formation.

This is especially important in the presence of solid particles, resin components, and corrosive-aggressive inclusions characteristic of the environment in gas processing plants. Comparative analysis showed that heat exchangers with improved channels require 2-3 times less cleaning than those with traditional smooth surfaces.

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