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ASSESSMENT OF THE EFFECTIVENESS OF VORTEX USE MASS TRANSFER EQUIPMENT AT SHURTAN GAS CHEMICAL COMPLEX

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Abstract: In the process of gas processing, mass transfer and mass transfer efficiency can be increased by creating optimal column regimes and effective column action mechanisms. In the absorption process, gas and absorbent are mainly affected in nozzle columns.

Keywords: absorber, Reynolds number, reactor, column, turbulent.

There are many different types of apparatus for organizing mass transfer processes in liquid-gas and solid-liquid systems [1]. The most common are column apparatuses of packed or plate design.

Recently, vortex mass transfer apparatuses have found wide application. Methods have been developed for stabilizing and obtaining stable gas-liquid and pseudo-liquefied (gas - dispersed solid phase) vortex layers in the vortex chamber of a vortex centrifugal multiphase reactor, which have a dense, ordered "quasi-crystalline" structure and are characterized by uniform jet flow around each particle with high Reynolds numbers and increased gas flow loads [2,3].

A mass-exchange apparatus design is known, the body of which is equipped with a second tangential slit for introducing the gas phase under a rotating liquid layer. The second slit is separated from the first by a partition and is located closer to the tangent, coinciding with the direction of phase introduction [4]. Such a design allows intensifying the mass-exchange process. The apparatus consists of a vertical cylindrical body with a tangential slit for introducing liquid, partitions separating them, a settling tank with pipes for removing the phases. The principle of operation of the apparatus is as follows: through the tangential slit of liquid introduction, a liquid phase is fed, forming a rotating layer, under which a gas phase is introduced from the second slit at a high speed (50-100 m/s).

The gas flow passes to the center of the housing through the liquid layer, turning it into a gas-liquid emulsion. In this case, the contact surface of the phases increases significantly, as a result of which the exchange processes are intensified.

Also known is a design of a mass exchange apparatus comprising a vertical cylindrical body, a distribution grid with distribution elements made in the form of truncated cones with the lower base down, a plate forming a gas chamber with the distribution grid and the body of the apparatus, in which conical injection-twisting devices are installed, made of hollow curved blades forming gaps between themselves, stunned from below, and communicating from above with the liquid level on the distribution grid through an opening, and forming a Venturi profile with the distribution elements [5]. The absorber has pipes for introducing liquid and gas, respectively.

In the proposed design of the absorber, due to the use of a swirling straight flow in the distribution zone, it is possible to create a highly turbulent gas-liquid flow with a continuously renewed phase contact surface.

Fig. 1 shows a graph of the dependence of the gas phase flow rate on the absorption of CO_2 by water in a vortex apparatus in the form of a function y=f(w).

Analysis of the graph shows that in all cases of using a vortex flow for the gas phase, the process of absorption of CO_2 increases, and with an increase in the value of the gas velocity, the absorption increases accordingly.

With a water velocity of $w_в$=0.3 m/s for gas with a velocity of 3 m/s, the concentration of carbon dioxide after absorption will be y=0.029 kg/m^3, with $w_в$=1.1 m/s the value y=0.017 kg/m^3, in the case of an increase in water velocity to $w_в$=2.05 m/s – y=0.0026 kg/m^3, i.e. with an increase in water velocity from 0.3 to 2.05 m/s the absorption intensity will increase by 11 times.

In case of gas velocity growth up to 5 m/s, the bubbling of gas-liquid flow will increase, i.e. vortex motion leads to growth of phase contact due to decrease of droplet sizes, as a result of which absorption of carbon dioxide by water increases. Thus, at water velocity $w_в$=0.3 m/s, concentration of carbon dioxide will be y=0.025 kg/m^3, at $w_в$=1.1 m/s value y=0.01 kg/m^3, and already at water velocity wв=1.55 m/s maximum absorption is achieved, i.e. y=0.0026 kg/m^3.

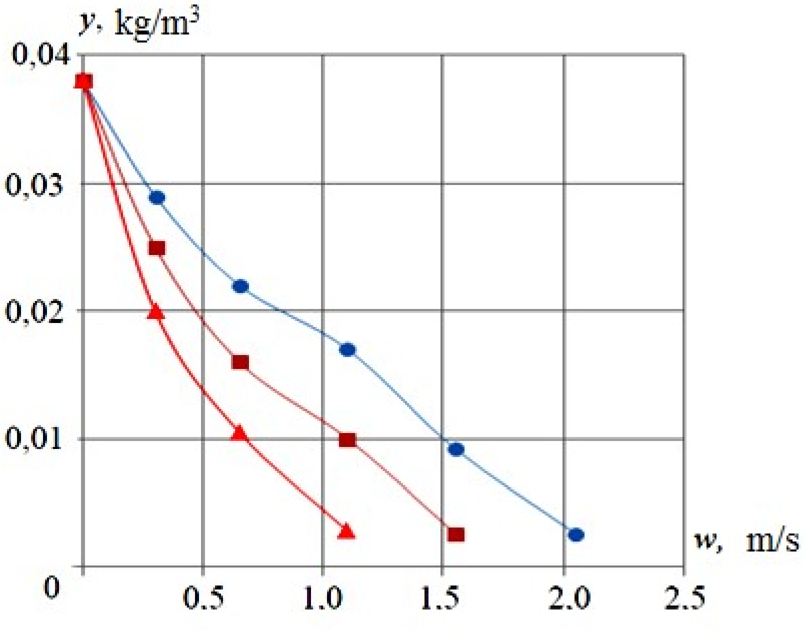

Fig. 1. The influence of the gas phase flow rate on the absorption of CO_2 by water in a vortex apparatus.

● – 2 m/s ; ■ – 5 m/s; ▲ – 8 m/s.

Analyzing the graph for a vortex absorber with a gas velocity of 8 m/s, all other things being equal, it can be seen that the absorption intensity, compared to a gas velocity of 3 m/s, increases by more than 6 times, namely, the maximum absorption of CO_2 is achieved at $w_в$=1.1 m/s, and compared to a gas velocity of 5 m/s, it increases by 3.5 times.

Advantages and benefits of vortex mass transfer devices: in a vortex fluidized bed, homogeneous fluidization is achieved at high gas flow rates with Reynolds numbers up to 5000 with a jet flow around each particle, which allows for processes to be carried out without the formation of stagnant zones, uniformly and with high efficiency in terms of heat and mass transfer; in a vortex gas-liquid layer, a high specific phase contact surface (5-10 m^2/l) is achieved with a high rate of its renewal and with high efficiency in terms of heat and mass transfer. In this case, there is no need to use packing that increases the phase contact surface. The reactor has small dimensions and high efficiency; the possibility of combining mixing and separation processes; low hydrodynamic resistance ($1\text{-}3\cdot10^3$ Pa), high gas throughput; simplicity of theoretical analysis and calculation of the main operating parameters of vortex multiphase layers; the ability to work with three-phase (gas-dispersed solid phase-liquid) vortex layers.

Based on the developed methods, multiphase reactors can be developed for carrying out specific chemical processes.

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