RESEARCH OF LIMIT LOADS IN OPPOSITE FLOWS IN ABSORPTION PURIFICATION OF GAS AND LIQUID FLOWS OF NATURAL GASES

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Abstract. *It has been scientifically substantiated that during the absorption purification of gas and liquid flows, the free volume of natural gases decreases during their two-phase movement, and tangential stresses arise on the contact surface of the phases owing to friction during their movement. The results of this study proved that in such a process, when the gas flow moves upward, the gas velocity decreases because of the backward movement of the flow and the force of gravity of the liquid. The obtained results prove that with a further increase in the gas velocity, the liquid begins to grow into the nozzle, and the possibility of determining it as a turbulence mode of a two-phase system on the surface of the hydrodynamic regime has been proven. The processes of its application in the purification of natural gases at the "Shurtan Oil and Gas Production Department," "Mubarek Gas Processing Plant," "Shurtan Gas Chemical Complex," and "Ustyurt Gas Chemical Complex" Ustyurt Gas Chemical Complex have been investigated owing to its high selectivity.*

Keywords*: two-phase, curtain mode, packing, emulsification mode, packing accumulation, standing mode, transparent packing.*

Introduction.

In the two-phase motion of a gas and liquid, the free volume decreases, and as a result of friction, tangential stresses arise on the contact surface of the phases. During two-phase motion, the interaction between the phases leads to an increase in the hydraulic resistance of the AP compared that with of the dry (non-irrigating) nozzle. This interaction can be neglected only at low phase speeds. When the gas and liquid move in opposite directions, four different hydrodynamic regimes are distinguished depending on the flow velocity (Fig. 1).

The first (Section A), called the curtain mode, occurred at low gas and liquid loads. In this mode, the phase interaction is insignificant, and the amount of fluid held (US-holding capacity) does not depend on the gas velocity. Section A, which represents the resistance of the irrigation nozzle, is a parallel line for dry nozzle I and is located above the nozzle with increasing irrigation density. Some researchers[1] have noted that this mode is one.

Above the 1st braking point, an intermediate fluid regime can occur during movement (Fig. 1, section B). The liquid covered the nozzle in the form of a thin flowing film and separate streams. Interfacial interactions occur on the surface of the film and liquid flows and at the points where the liquid contacts the individual elements of the nozzle. In film and fluid flows, a slowdown is observed with the formation of individual gas-flow vortices [2].

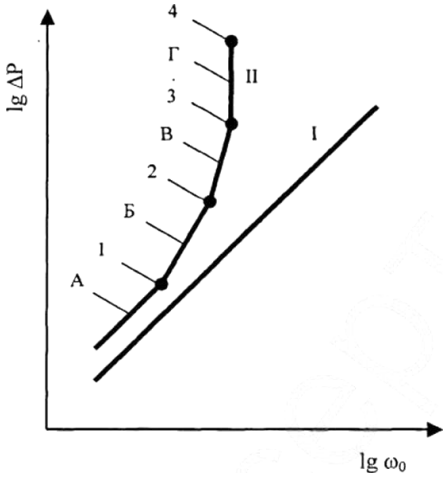


Figure 1 - Hydrodynamic regimes for a two-phase system in the columns of a two-tailed nozzle and their transition points:
I - for dry nozzles, II - during irrigation; A - curtain mode; B-intermediate mode; B-turbulence mode of the two-phase system; G-emulsification mode; 1 - stability point; 2 - hanging point; 3 - phase acceleration point; 4 - suffocation point.

With a further increase in gas velocity, the liquid began to grow on the nozzle (point of suspension 2), whereas the opposite flow was maintained by the moving gas. An increase in US with an increase in gas velocity led to a decrease in the free volume of the nozzle and a rapid increase in resistance. The liquid and gas phases interact on the surface of the turbulent fluid film and can therefore be defined on the surface of the hydrodynamic regime as the turbulent regime of a two-phase system (Section B).

Further accumulation of liquid in the nozzle and the interaction between the flows and wetted surface of the nozzle led to its transition into its volume. The accumulation of liquid primarily began at the bottom of the nozzle and gradually spread throughout the entire height. This is characterized by the emergence of a fundamentally new hydrodynamic regime: the emulsification regime (Section G).

Emulsification mode, a field of free enhanced turbulence, occurs in the packing columns after the phase intensification point. Increased turbulence in each phase of the packing volume leads to turbulent pulsations on the phase separation surface. In this mode, the concept of dispersed and continuous phases loses its meaning because the phases are constantly inverted, transforming into gas or liquid, continuous or dispersed phases. In this case, the phases pass through countless small whirlpools[2].

Under such conditions, a stable hydrodynamic system of "emulsified" liquid exists, in which gas vortices arise and move while penetrating the circulating liquid, in which liquid vortices also arise and move. Unlike the first two points (gas stability point and liquid suspension point), the acceleration point is always sharply visible and well-defined.

According to the studies of Planovsky and Kafarov [3] and several other authors [4, 5, 6], the choking mode corresponds to the maximum efficiency of the nozzle column. The high efficiency in the choking mode is explained by the large contact area of the phases, which is determined not by the geometric surface of the nozzle but by the conditions of the impacts.

The 4th choking point corresponds to conditions in which the height of the gas-liquid (vapor-liquid) emulsion layer is greater than the height of the packaging layer, and a liquid layer accumulates above the nozzle, which is a foam layer with sedimentary mixing.

The final mode (cultivation mode) occurs when the gas velocity exceeds the value corresponding to the countercurrent mode. In this case, intensification of the secondary phase occurs: the gas again transforms into a continuous phase, and the liquid, along with the gas, is carried out from the apparatus, mainly in the form of splashes. Simple filling irrigation was performed.

This mode is accompanied by a sharp decrease in the intensity of mass transfer. The access mode is not used and is therefore unexplored. According to [3], in this mode, the increase in resistance slows down, and the curve of DR's dependence of the DR on the gas velocity proceeds with approximately the same slope as in the curtain mode. The point corresponding to the transition to the input mode characterizes the maximum load of the device.

Materials and Methods

Experimental studies by many authors [2, 7, 8, 9] on the determination of the suffocation point were determined by the following equations:

1) With an increase in irrigation density, suffocation occurred at a lower gas velocity. In the absence of gas movement, a dependence was observed at high irrigation densities.

2) At the same irrigation density, the gas velocity corresponding to choking is higher at higher values of the equivalent nozzle diameter.

3) With the same dimensions of the packing elements, the lower the load limit for gas and liquid, the lower is the empty volume of the packing.

For packed columns, the critical state is considered to be maintained (accumulation of liquid in the packing) or evaporation of the packing (when the liquid layer accumulates over the winding, which is a foam layer with rapid mixing) [2].

At the limit load of the column, the final loads of the packing columns are determined according to the same laws as those of traditional packing columns; however, in most cases, the beginning of the suspension mode is considered an important point in the operation of the packing [2, 9].

Thus, considering the foregoing, the objectives of studying the maximum loads of the developed two-tailed packing column include:

The gas phase velocity corresponding to the beginning of the suspension regime in the layer of the two-tailed nozzle column, as well as other studied nozzles (for comparison with the usual: an irregular nozzle made of angular, X-shaped, and Rashig rings, and a column of two-tailed nozzles) were determined by the gas flow and liquid phase.

- A mathematical model is found that adequately describes the results obtained from the experimental studies.

According to the adjustment shown in Fig. 1, the velocity of the gas phase in the entire cross-section of the column was determined, corresponding to the start of the holding mode. The obtained data are presented in table.

The values of the gas phase velocity corresponding to the hanging mode of the Rashig rings for the nozzle were calculated using the generally accepted Beyne-Hougen equation [2, 8, 9, 10, 11] for the experimental conditions:

$$\lg\left[\frac{\omega_r^2 \cdot f}{g \cdot \varepsilon_{CB}^3} \cdot \frac{\rho_r}{\rho_æ} \cdot \mu_æ^{0,16}\right] = \hat{A} - \tilde{N} \cdot \left(\frac{W_{Æ}}{W_r}\right)^{0.25} \cdot \left(\frac{\rho_r}{\rho_æ}\right)^{0.125} \quad (1)$$

here ω_r - gas velocity in the entire column cross-section, m/s;

ε_{CB} - Free volume of packaging, m^3/m^3;

f - specific surface area of the nozzle per unit volume, m^2/m^3.

ρ_r, $\rho_æ$ - density of gas and liquid phases, kg/m^3; - dynamic viscosity of the liquid phase, Pa-s; W_r,

W_J - mass flows of gas and liquid phases, kg/ (m-hour);

B and C - corresponding coefficients for different types of nozzles.

For Raschig rings of the selected size (ceramic, 25x25x3), according to various sources, the following data are provided. [2, 8, 9, 11]: = 0,74 m^3 / m^3; f = 200 m^2 / m^3.

Coefficients of equation 3.1 for the condition of the beginning of the gas suspension regime in the layer of the nozzle column [12]: B = - 0,073 and C = 1,75.

Conducting a series of parallel experiments using blocks of a transparent nozzle column according to the method described in Section 3.5 of this dissertation for the studied continuous nozzles showed that the beginning of the gas-phase suspension mode is determined uniquely within the range of the gas and liquid phase flow rate measurement error of no more than 3% (Table 1, Appendix A). Thus, it can be assumed that the values of the gas phase velocity in the entire cross-section of the experimental column, presented in Table 1 (Appendix A), can be completely reliably repeated.

Results and Discussion

The graphs in Fig. 1 show that the velocity of the beginning of the suspension mode in bi-tailed and angular nozzles between the most common gas and liquid loads is practically the same (rows 1 and 2). This circumstance can be explained by the anatomical structure of the column of the tested nozzles. Double-tailed and simple-angled nozzles also have a strictly defined cellular structure of the nozzle column structure. The gap size for both nozzles was 0.015 m.

According to the experimental values of the critical velocity in the entire cross-section of the column for the tested nozzles, presented in Table 1, graphical dependencies are constructed in Fig. 2.

Data on gas phase velocity ω_r corresponds to the beginning of the hanging mode in the full section of the column.

Table 1

($W_{Æ}$ / $W_{r)}$	L/G	Double-tailed nozzle	X-shaped nozzle	Angular nozzle	Rashig rings
1	2	3	4	5	6
5,359	0,0065	1,177	0,969	1,159	0,939
5,824	0,0070	1,146	0,946	1,127	0,914
6,306	0,0076	1,116	0,923	1,097	0,889
6,807	0,0082	1,087	0,902	1,069	0,866
7,327	0,0088	1,059	0,882	1,042	0,843
8,834	0,0106	0,990	0,831	0,974	0,788
9,429	0,0114	0,967	0,813	0,950	0,768
10,049	0,0121	0,944	0,796	0,927	0,750
10,581	0,0128	0,925	0,782	0,909	0,735
11,371	0,0132	0,900	0,772	0,896	0,714
15,252	0,0184	0,798	0,686	0,784	0,633
20,235	0,0249	0,705	0,609	0,686	0,558
26,006	0,0313	0,627	0,553	0,615	0,495

33,475	0,0410	0,553	0,491	0,537	0,436
41,721	0,0503	0,492	0,446	0,482	0,387
52,300	0,0615	0,434	0,404	0,431	0,340
62,909	0,0758	0,389	0,362	0,381	0,305
85,979	0,1048	0,320	0,302	0,310	0,250
106,510	0,1282	0,277	0,268	0,271	0,216
134,369	0,1599	0,235	0,233	0,232	0,183
174,332	0,2102	0,194	0,194	0,188	0,150

From the experimental data presented in the form of graphs in Fig. 2, it can be seen that the X-shaped nozzle has a smaller range of maximum loads for gas and liquid, which is due to the design features of the nozzle. Thus, with the equality of the total area of the gap gaps, the width of the gaps marked on the X-shaped nozzle was 0.01 m.

The speed of starting the gas phase retention mode in the two-tailed nozzle device is 19% higher in the studied range, it should be noted that with an increase in the L/G ratio, the difference in the permissible gas velocity values decreases.

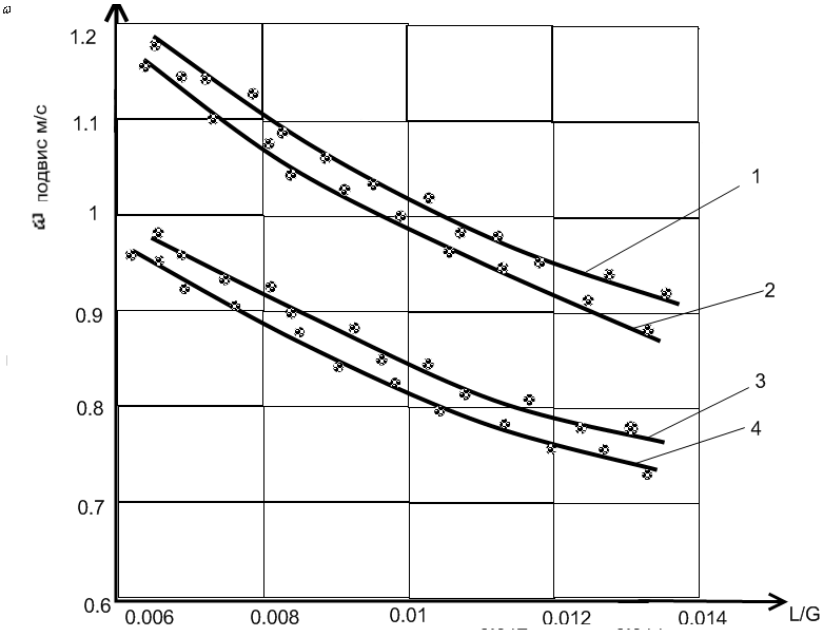


Figure 2. Comparison of initial suspension speeds in different nozzles.

1 - two-tailed nozzle; 2 - angular column; 3 - X-shaped nozzle; 4 - Rashig rings.

Conclusion

When comparing the values of the gas phase velocity corresponding to the beginning of the suspension mode of suspension Re in the two-tailed gas-phase nozzle device with the calculation for the Rashig rings, the difference was found to be 20–22%. It should be noted that with an increase in the load of the liquid phase, the difference in the values of the suspension velocities of the two-tavr nozzle device and the Rashig rings increased.

The experimental data presented in the form of graphs show that the X-shaped nozzle has a smaller range of maximum loads for gas and liquid flows owing to the design features of the nozzle. Thus, with the equality of the total area of the gap gaps, the width of the gaps marked on the X-shaped nozzle was 0.01 m.

The speed of starting the gas-phase shutdown mode in the two-tailed nozzle device was 19% higher in the studied range.

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