Creation of Highly Effective Devices for Purification of Natural Gas

Rahmonov T. Z.

Candidate of Technical Sciences, Associate Professor. Chief Specialist of “LUKOIL Uzbekistan Operating, Company”, Olmazor st.1a, 100027 Tashkent, Republic of Uzbekistan

Abstract - By results of pilot and industrial studies of a mesh plate with two zones of contact with the free section of 20 % new data on gas-filling of a bubbling layer, hydraulic resistance and a thaw ablation in the wide range of change of loadings on gas and liquid are obtained; the area of steady and effective work of the studied design of a mass-exchanged plate is defined, the empirical equations for calculation of optimum hydrodynamic parameters are received and the comparison of experimental and settlement data testifying adequacy of the received equations is executed.

Keywords – natural gas, liquid drops, gas condensate, reservoir water, hydrogen sulfide, amine solution, carbon dioxide.

I. INTRODUCTION

Now on the majority of gas and gas-condensate fields of Uzbekistan there is a noticeable decrease in reservoir pressure of natural gas that moisture at the exit from separators conducts to increase in its initial moisture content, increase of speeds of gas in technological devices, to ablation increase. All this reduces quality of preparation of gas, reduces reliability of work of the equipment, worsens an ecological situation on objects of preparation and processing of natural gas.

Besides the equipment used for complex purification of gases of liquid and sour components, in particular, at the gas-processing enterprises needs radical reconstruction and modernization. The most part of devices of installations of complex preparation and purification of gas at the enterprises of the Republic of Uzbekistan was developed 25-30 years ago and not fully conforms to today's strict requirements. At the same time, with development of new technologies in the conditions of economic and ecological crisis there is actual a question of decrease in a material capacity of the equipment, an economical expenditure of raw materials and energy resources.

The main technological devices and cars of branch imported from foreign countries fulfilled the resource, and demand replacement that very aggravates need of development of the modern compact equipment and their production at machine-building enterprises of Uzbekistan.

At this conjuncture creation of highly effective devices and contact devices for an intensification of technological processes of complex purification of natural gas of the liquid and sour components proceeding in gas-liquid systems represents actual and demanded scientifically – a technical problem [1, 2].

An analysis of the directory inquiries, scientific, technical and patent literature, as well branded materials, information relating features of a design, the destination, operational characteristics of different types of contact devices has shown that for large-scale production the newly issued blocks absorption desulfurization apparatus are pawned plate, column with valve assembly, perforated, bubble cap plate, and other plates of the barbotage principle action.

In connection with the low velocity gas in the cleaned of data columned devices (up to 2m/s), their diameter varies between 4.5 to 6.0 metres and the height because of with low of mass transfer efficiency may be higher than 60 m.

With increasing diameter apparatuses increases disordered motion interacting phases appear on a plate “bypass” flow, “dead” zone, a transverse unevenness of gas flow velocity and height of liquid on the a plate. All this reduces the efficiency of the mass transfer column. In this connection the device should enhance performance the creation of contact devices having high performance for liquid and gas.

Enormous capital costs, due to the large overall dimensions and accordingly high – cost apparatus absorption – desorption cycle, imposes a heavy the cost price a burden on the cleaning processes of gases in large operating costs.
In recent years, the Swiss company “Sulzer” [3], German firms “Chemieanlagenbau Chemintz GmbH (CAC)”[4] and “Juliuont Montz GmbH” [5], the Italian company “Koch – Glitsch” [6], the American company “Norton Chemical Products Corporation” [7], Russian firms SKBN (Moscow) [8] and “PETON” (Ufa) [9], the Austrian company Intalox High –Performance Structured Packing [10], developed new checker work separation and mass transfer device in the form of metal stamping, corrugated, perforated plates and polymer openwork designs.

Ease lances are working in a purely thin film regime, which the possesses all the disadvantages of film apparatus: the huge complexity of the uniform distribution of the liquid phase over a large surface of mass transfer; high gas slippage without contacting with the liquid through the exposed portions of nozzle; a small velocity of the gas, etc.

One of directions of technical progress in the chemical, petrochemical and refining industries – the development and application apparatus large unit capacity. It should be the creation of the technologies and new of more compact and efficient equipment for the cleaning of natural gas from the liquid and sour of impurities is an urgent task for all countries of the world [11-14].

It is noted that in the turbulization systems gas in liquid of high intensity are created on plates of mass-exchanged devices. The surface of contact of phases of gas-liquid system is defined by the sizes of phase cells and gas content. The volume of a bubbling layer is defined by expression:

\[ V_c = HF_c \]  

(1)

Where, \( H \) – height of a layer, m; area of section of a layer, \( m^2 \).

The quantity of the drops weighed in a stream, during the operation of the device in the intensive modes, is defined by technological indicators of process – the speed of gas and density of an irrigation. The amount of liquid which is in the device in case there is no its accumulation in the device at the expense of a difference of speeds of gas and liquid is defined by expression:

\[ G_s = V_{av} \rho_l B, \]  

(2)

Where, \( B \) – specific irrigation, kg l/kg gas.

The amount of liquid passing through the device in unit of time \( q_l \), kg/s at the density of irrigation of \( L \), m/s is defined as:

\[ q_l = L \cdot F_c \cdot \rho_l, \]  

(3)

The amount of \( q_l \) gas, kg/s at a speed is expressed as follows:

\[ q_r = U_{av} F_r \rho_r, \]  

(4)

The specific irrigation is defined by expression:

\[ B = \frac{q_l}{q_r} = \frac{L \rho_l}{U_{av} \rho_r}, \]  

(5)

The total amount of liquid in the device

\[ V_{ik} = \frac{G_s}{\rho_l} = \frac{LFH}{U_{av}} \]  

(6)

Taking into account sliding coefficient, \( i = \frac{W}{U_{av}} \) we will receive,

\[ V_i = \frac{LFH}{iU_{av}} \]  

(7)

Using expression (10), we will express gas content through technological parameters of process:

\[ \varphi = \frac{V_{sk} - V_l}{V_s} = 1 - \frac{V_i}{V_s} = 1 - \frac{L}{iU_{av}} \]  

(8)

In case the part of the liquid coming to a gas-liquid layer is in a condition of bubbling, the quantity of drops in the system is defined with an indicator of a relative splashes ablation \( e \) and is determined by expression

\[ n_k = \frac{LeF_H}{AiU_{av}d_k}. \]  

(9)

Where \( A \) – the form coefficient.

As a result of theoretical researches, the interrelation between quantity of phase cells and gas content of a two-phase layer in the intensive bubbling modes which are created on plates of columned devices and systems with a gas disperse phase is defined.

For an assessment of ability of the equipment to bear loading on gas it is offered to use, \( F \)-the speed factor which is work of the actual speed of gas per the full section of a column \( (U, m/s) \) on a root square from the actual density of gas \( \rho, kg/m^3 \) in the columned device:

\[ F = U \sqrt{\rho}. \]  

(10)
Use of $F$-of a factor of speed to an assessment of intensity of operation of contact devices of gas-liquid dividers (a separator and a decontaminator) and mass-exchanged columned devices (an absorber and a desorber) allows to apply results of laboratory researches in the industry.

Results of researches of hydrodynamic parameters of a mesh plate are given with two zones of contact of phases (fig. 1) in relation to mass-exchanged devices – to an absorber and a desorber of installation of purification of natural gas [15]. The offered mass-exchanged plate differs in the big range of working loadings on gas and liquid, the small hydraulic resistance and higher rates according to mass-exchanged characteristics. These plates can work at $F$-values of a factor 2÷3. We will note that the plates which are operated at gas-processing plants work at $F$-value of a factor of $F \leq 1$.

At a modulation of solution the curtain is created “liquid” that allows to contact in addition liquids to gas. In an overflow glass the defoaming agent made of corners is installed. The defoaming agent serves for removal of gas and subjects promotes increase in capacity of overflow devices.

For the purpose of an assessment of hydrodynamic characteristics of plates with two zones of contact of phases at the raised loadings on gas and liquid tests of a model plate at

Experiments were made in the following range of parameters: gas speed in the free section of a column from 0.8 to 2.5 m/s that corresponds to a $F$-factor in the range of 1.0÷2.9. Range of density of an irrigation was changed from 20 to 75 m³/m³h that corresponds to load of the length of threshold from 5.1 to 19.1 m³/mh.

At researches gas-fillings are determined by height of a bubbling layer, splashes ablation and the hydraulic resistance of plates in the range of working loadings on gas and liquid and the range of steady work of a plate.

In fig. 2, as an example regularities of change of gas-filling at various $F$-values of a factor are illustrated. According to schedules growth of gas-filling at low values of density of an irrigation when kinetic energy of gas prevails over potential energy of liquid is visible and is in limits 0.7÷0.8. The received dependences of gas-filling on working parameters show that the operating mode of a plate with the free section of 20% reaches to $F = 2.84$.

On each mode measurements of pressure difference with the $U$-shaped differential manometer of water filling were taken.
From fig.3 it is visible that with increase in a volume consumption of liquid at unit of a mass-exchanged plate, i.e. irrigation density, the noticeable growth of hydraulic resistance is observed. Thus it is established that the increase in speed of gas doesn’t lead to the sharp growth of the studied parameter.

For experimental definition of ablation during the work in air-water system the column with a diameter of 300 mm supplied with two mesh plates with two zones of contact which free section was changed in the % F1=10÷20 range was used. Thickness of plates made 6 mm, diameter of an opening – 9,4 mm, distance between plates - 500 mm.

For catching of the drops which are carrying away through the top part of a column used the cyclone established on the line of an air outlet. Ablation was expressed through the attitude of amount of the carried-away liquid towards quantity given, i.e. relative ablation, in kg/kg.

Dependence of relative ablation of drops from a plate with the free section of 20%, from F factors of speed is given in fig. 4 at various density of an irrigation. With increase in density of an irrigation relative ablation and speed limits of gas decrease owing to growth of a layer of liquid on a plate and faster stopping of the device. In the conditions of the made experiments speed limits of gas made 2,4÷2,6 of m/s (F = 2,7 ÷2,9).

The equation is fair for H=500÷600 of mm, F1=10÷20 of %, L=20 ÷75 m3/m² h, U=0,8-2,5 m/s also has accuracy ±10% for 96% of experimental data.

As a result of processing of experimental data we received the dependence allowing to define relative ablation of liquid depending on technological parameters of process and free section of a plate:

$$e = 0,75 \times 10^{-3} U^{1,8} L^{-1,3} F^{-2,5},$$

(12)

The equation (12) is fair for H=500÷600 of mm, F1 = 10÷20 of %, L = 20 ÷75 m3/m² h, U=0,8-2,5 m/s also has accuracy ±10% for 96% of experimental data.

For an assessment of possibility of effective functioning of a column at various loadings on gas and liquid usually use area of its steady work which depends mainly on type and a design of the contact device.

Range of steady work of plates is determined by a combination of loadings by gas and liquid. In fig.5 described the area of steady work of the plate investigated by us, respectively, received by generalization of considerable volume of experimental data. The schedule is constructed in coordinates "a speed F-factor -L – irrigation density". The most admissible F-a gas speed factor in a column (BC line) is defined by liquid ablation size. The AD line determines minimum admissible speeds of gas, the corresponding 10% to a liquid failure.
On the right the area of steady work is limited to the CD line which corresponds to the maximum loadings on liquid, the corresponding 85% of the mode of a stopping. The AB line define the minimum loadings on liquids at which on a plate the steady bubbling layer is provided. Loadings on gas and the liquids corresponding to coordinates of any point in area provide steady functioning of the device.

It is shown that modified an absorber with plates of new type allows to increase device productivity by 1,4 times of the relative design; the effect is reached at the expense of an intensification of process of absorption at preservation of high rates of quality (no more than 7 mg/m² of H2S in the cleared gas) purification of natural gas.

II. CONCLUSIONS

Thus, as a result of research optimum hydrodynamic indicators are defined and the area of steady work of a plate for carrying out absorbing and stripping processes with high intensity in courses of mass-exchanged processes small-sized technological devices is revealed.

REFERENCES