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HIGH-PERFORMANCE NOZZLE ABSORBER FOR DRYING NATURAL GASES WITH HIGH MOISTURE CONTENT

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Abstract. The article covers the data on the design and principle of operation of the absorber with cyclonic spray, which is highly effective in drying natural gases in older gas wells with lower formation pressure and correspondingly higher moisture content.

Keywords: absorber, desorber, natural gas, glycol solution, diethylene glycol, triethylene glycol, gas drying, gas, cyclone absorber.

Аннотация. В статье приведены данные о конструкции и принципе работы абсорбера с циклонным распылением, который высокоэффективен при осушении природных газов в старых газовых скважинах с более низким пластовым давлением и, соответственно, более высоким содержанием влаги.

Ключевые слова: абсорбер, десорбер, природный газ, раствор гликоля, диэтиленгликоль, триэтиленгликоль, осушка газа, газ, циклонный абсорбер.

Annotatsiya. Maqolada tabiiy gazlarni quritish uchun juda samarali bo'lgan siklonik purkagichli absorberning konstruktsiyasi va ishlash printsipi haqidagi ma'lumotlar keltirilgan. Bu gaz quduqlari qatlam bosimi past va shunga mos ravishda namlik miqdori yuqori bo'lgan eski gaz quduqlarida qo'llaniladi.

Kalit so'zlar: absorber, desorber, tabiiy gaz, glikol eritmasi, dietilen glikol, trietilen glikol, gazni quritish, gaz, siklon absorber.

INTRODUCTION.

Produced natural gas is saturated with water vapor. The amount of water vapor depends on the pressure and temperature of layer and its chemical composition. During the operation of the well, the formation pressure gradually decreases and the water content of natural gas increases accordingly.

Therefore, the decrease in formation pressure and the increase in moisture content of extracted natural gas are the factors affecting the change of technological parameters of drying devices with the help of glycols. Formation pressure affects not only the working pressure, but also the moisture content of produced gas. As the formation pressure decreases, the equilibrium moisture

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content in the gas composition increases. As a result, the amount of moisture extracted in the absorber increases accordingly.

The linear speed of the gas in the device increases with the decrease in pressure while maintaining the volume of the produced gas, as a result, it has a negative effect on the operation of drying devices with glycols. In particular, droplet removal of liquid in separators is accelerated. It is known that the liquid contains mineral salts and mechanical additives. These substances are absorbed by the glycol solution and increase in quantity, as a result of which the properties of the glycol are reduced. Moreover, as the speed of natural gas passing through the absorber increases, the amount of absorbent carried in the gas transmitted to the main pipeline increases. It has been proven by experiments that the value of droplet removal is inversely proportional to the working pressure in the device. Currently, this problem is solved by increasing the efficiency of the filtering section of the absorber. The pressure is the main factor that determines the metal costs of the absorber, the relative cost of the absorbent, and the energy costs of circulation pumps.

LITERATURE REVIEW AND METHODOLOGY.

The absorber is a multi-functional device, consisting mainly of three parts: separation, mass exchange and filtering parts. The separation part is designed to separate water in the form of drops in natural gas. Water in the form of steam in natural gas is absorbed and separated into glycol in the exchange part. In the filtering part, the droplet-shaped absorbent remaining in the dry gas is separated [1].

Nozzle columns have a number of advantages: the structure is simple and it is possible to work with liquids that cause erosion of the inner surface of the equipment. Such equipment can be used when the value of the diffusion resistance in the transfer of matter is large in the liquid or gas phase. Such equipment is not without its shortcomings. Contaminated or turbid liquids cannot be used in nozzle columns. In such columns, it is difficult to remove the heat released during the absorption of gases, besides, the nozzles are poorly moist when the amount of splashing of liquids is small. The method of recirculating absorbents through a pump (that is, returning a certain part of the absorbent to the column) is used to reduce the heat generated in this equipment and to moist the nozzles well.

For the nozzles to work effectively, the following requirements must be met: 1) the nozzles have a large surface per volume unit; 2) good mixing with dispersing liquid; 3) low hydraulic resistance to gas flow; 4) uniform distribution of dispersible liquid; 5) to be chemically resistant to the effects of liquids and gases moving in the column; 6) low specific gravity; 7) mechanically strong; 8) it should be cheap. But in practice, there are no nozzles that meet such requirements,

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for example, a large surface area leads to an increase in the hydraulic resistance of the equipment.

RESULTS AND DISCUSSION.

Vertical columns filled with solid bodies of various shapes and sizes, that is, nozzles, are widely used in industry due to their simple structure and high efficiency. In nozzle columns (Fig. 1), the nozzles are installed on the support bars 5 through which gas and liquid pass. The internal cavity of the equipment is filled with nozzles 2 or placed in layers with a height of 1.5-3 m each. Gas is supplied to the bottom of the grid through the gas distributor 6, and then passes through the nozzle layer.

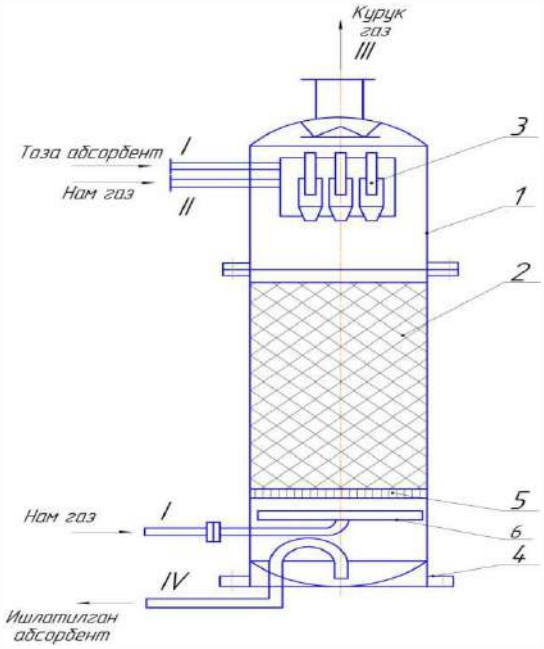


Fig. 1. Nozzle absorption column:
1- absorber shell; 2- nozzle layer; 3- battery cyclone sprayer; 4- absorber base; 5- base grid; 6- gas distributor.
I- moist gas; II- pure absorbent; III- dry gas; IV- used absorbent.

Absorbent mixed with moist gas is sprayed from the upper part of the column through special battery cyclone decanters, it meets the gas flow from below while passing through the nozzle layer. In order for the column to work efficiently, the liquid must be uniformly distributed over the entire cross-section of the equipment. In this equipment, the contact surface is formed using nozzles.

Cyclone spray (Fig. 2) consists of case 1 with a diameter Dk = 200 mm, the tangential inlet 2 of absorbent liquid with a diameter of d=30 mm, dry gas outlet 3 with a diameter d=50 mm, tangential natural gas inlet pipe 4 with a diameter d=50 mm, and nozzle 5 for spraying moist gas and absorbent mixture on the nozzle layer with a diameter of d=50 mm. In order for the absorbent flow entering the cyclone to form a thin curtain in the gas flow inside the wall, the absorbent

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and gas inlet nozzles are placed at an angle of 30° degrees to each other. The absorbent inlet is placed above the gas inlet.

The length of the cylindrical part of the cyclone is 3d. The cone angle of the cyclone also affects the spray level. A reasonable size of the angle is 5°. A decrease in the angle has a positive effect on the quality of spraying, but the size of the device increases.

The device works in the following order. The recovered absorbent from the desorber flows to the cyclone 1 through pipe 2. The high-pressure wet gas compressed in the compressor is transferred tangentially at high speed through nozzle 1. The gas circulating in the cyclone mixes rapidly with the absorbent and forms a thin film on the inner wall of the cyclone. The mixture of gas and absorbent is highly turbulated. Due to the turbulation of the gas and absorbent mixture, mass exchange takes place at a high speed, and the dried gas is removed from the cyclone through nozzle 3. The concentrated absorbent is sprayed over the nozzle layer through nozzle 5. The absorbent continues to participate in the process in the nozzle layer and is removed from the absorber in a saturated state and transferred to the desorber for regeneration.

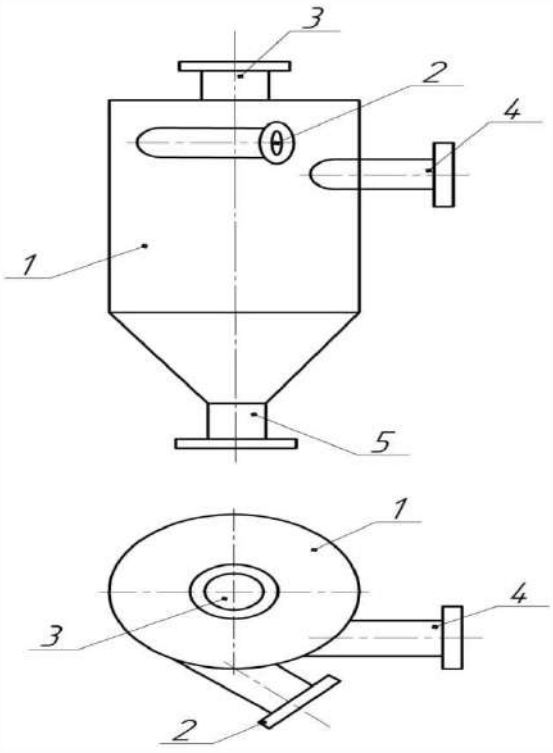


Fig. 2. Cyclone sprayer

1- cyclone; 2- absorbent inlet pipe; 3- dried gas outlet nozzle; 4- moist gas inlet pipe; 5- nozzle for spraying unsaturated absorbent on the nozzle layer.

In order to determine the effectiveness of the proposed cyclone sprayer, experiments were conducted. In the experiments, the physical parameters of the

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gas were taken as follows: molar mass – 0.03 kg/mol; density – 1.49 kg/m^3, viscosity – 1.82*10^{-5} kg/(m*sec); normal mass speed - 20 m/sec; pulsation – 0.01, turbulence scale – 0.00254. As a result of the experiments, a full speed distribution graph was obtained for different options H= d, H=2d, H=3d on the cross section of the cyclone sprayer.

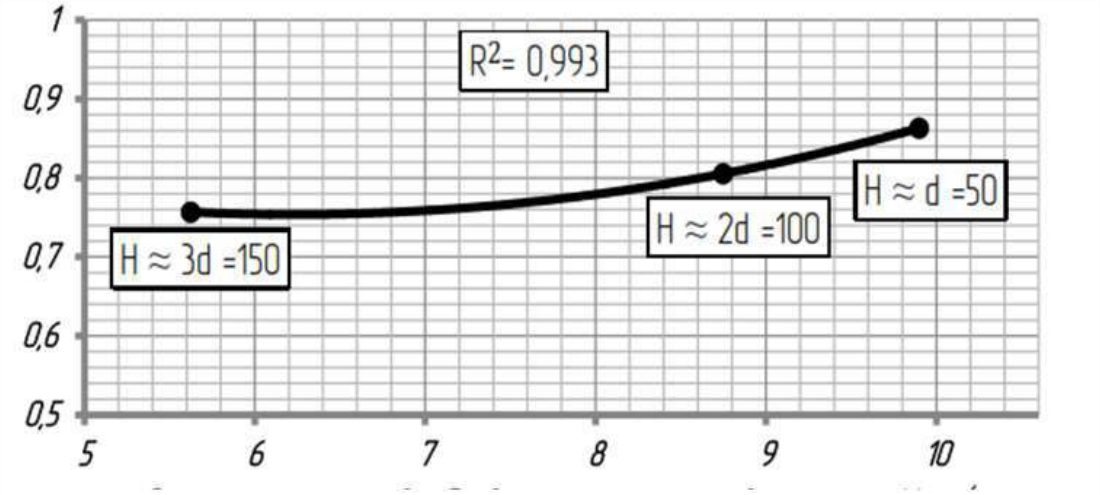
The data obtained as a result of the experiment are presented in Table 1. Experiments show that the efficiency of mass exchange increases with the increase of gas speed at the entrance to the cyclone. This depends on the height of the tangential gas inlet nozzle and the absorbent inlet nozzle. [4,5,6]

Based on the obtained results, the dependence of the mass exchange efficiency (L/G = 2.5) on the gas speed was determined (Fig. 3).

As can be seen from the figure, the efficiency of mass exchange increases with the increase of gas speed (as the height of the gas inlet nozzle decreases).

The use of this spray allows the gas drying process to be carried out in a centrifugal force field. As a result of the increase in the speed of the phases, the flow turbulence increases and the thickness of the film decreases. Due to turbulation, convective matter exchange is accelerated.

Mass exchange efficiency



Gas inlet speed through the tangential nipple, V m/s

Fig. 3. Dependence of mass exchange efficiency (L/G = 2.5) on gas speed

As a result of the increase in gas and absorbent speed, the performance of the device increases. The structure of the device is simple, and it is not difficult to prepare its elements.

This recommended battery-operated cyclonic spray absorber is highly effective in drying natural gases in older gas wells with lower formation pressure and correspondingly higher moisture content.

CONCLUSIONS.

As a result of the conducted research, the following can be concluded:

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1. Based on the analysis of the effectiveness of existing absorption devices and taking into account their shortcomings, in the absorption drying of natural gas it is promising to use a cyclone spray absorber, which is free of disadvantages such as multiple objects, large dimensions and high metal costs.

2. Comparison of different variants of the cyclone spray absorber with nozzle placed at different heights showed that in all variants the full speed increases from the axis of the cyclone absorber towards the edge.

3. It has been established that the appearance and character of the full speed distribution graph does not change with the increase in the height of the nozzle. Therefore, it is not advisable to increase the location of the nipple.

4. Conducting experiments in the experimental device, the law of dependence of the efficiency of mass exchange on the height of the tangential tap in relation to the turning surface was studied, and it was determined that the highest efficiency in the constant consumption of gas is at H=d.

5. It has been established that the efficiency of mass exchange increases with the increase of gas speed supplied through the tangential nozzle. This is done by adjusting the placement height of the gas inlet tangential nozzle. The highest efficiency was $E_u = 0.863$ at H/d and L/G = 2.5.

6. Based on the conducted experiments, the law of dependence of the efficiency of mass exchange on the location height of the nozzle in the cyclone absorber with a tangential pipe diameter of 50 mm was determined.

7. It is appropriate to introduce a small-sized, high-speed cyclone absorber in order to reduce the technological equipment in the natural gas absorption dryer, their overall dimensions and metal costs, and, of course, the capital costs necessary for the construction, operation and maintenance of the device.

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