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ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ

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HYDRAULIC RESISTANCE OF THE ADSORBER WITH REGULAR NOZZLE

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Abstract. Adsorption-type devices are widely used for drying and purifying natural gas. The adsorption process occurs effectively if the contact surface of the gas and liquid phases is larger. In this regard, adsorbents made of highly porous materials are used. The hydraulic resistance of an adsorber with a regular nozzle is considered. The main features of the operation of this attachment are determined. A decrease in the porosity of the nozzle and an increase in the length of the path of gas flow compared to a fixed adsorbent layer have been established. These features of the nozzle are taken into account when deriving equations to determine the hydraulic resistance of an adsorber with a regular nozzle. The heat and mass transfer characteristics of a regular packing were assessed. Results. Calculations of the hydraulic resistance of an adsorber with a regular packing show that the porosity of a regular packing is reduced by 3%, and the length of the gas movement path and, accordingly, hydraulic resistance of the packing layer increases by 11.8% due to the presence of bodies of rotation in the layer. All this leads to a more efficient process of heat and mass transfer, uniform distribution of gas flow in the cross section of the adsorber. Scientific novelty. As a result of the conducted research, calculated dependence of hydraulic resistance was obtained, which leads to significant changes in the flow dynamics. Practical value. The results of the study can be used to develop efficient adsorbers, which will lead to a reduction in operating costs and an increase in productivity.

Keywords: adsorber, process, heat and mass transfer apparatus, nozzle, hydraulic resistance, gas.

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АДСОРБЕРДІҢ РЕТТІ САПТАМАСЫНЫҢ ГИДРАВЛИКАЛЫҚ КЕДЕРГІСІ

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Аннотация. Табиғи газды кептіру және тазарту үшін адсорбциялық типтегі құрылғылар кеңінен қолданылады. Газ және сұйық фазалардың жанасу беті үлкенірек болса, адсорбция процесі тиімді жүреді. Осыған байланысты өте кеуекті материалдардан жасалған адсорбенттер қолданылады. Адсорбердің ретті саптамасының гидравликалық кедергісі қарастырылды. Осы сараптама жұмысының ерекшеліктері анықталды. Қозғалмайтын адсорбентке қарағанда саптама кеуектілігінің кемитіні және онда қозғалатын газдың жүру жолы ұзаратыны анықталды. Бұл ерекшеліктер ретті саптаманың гидравликалық кедергісін есептеуге арналған теңдеуді қорытуда ескерілді. Ретті саптаманың жылу масса алмасу мінездемелері бағаланды. Нәтижелері. Адсорбердің ретті саптаманың гидравликалық кедергісінің есептеулері ретті саптаманың кеуектілігі 3%-ға азаяды, ал газ қозғалысы жолының ұзындығы және сәйкесінше орау қабатының гидравликалық кедергісі қабатта айналу денелерінің болуынан 11,8%-ға артады. Бұл әдеттегі қаптама қабатындағы газдың зигзагты қозғалысына байланысты. Бұл кезде газ ағынының турбилизация дәрежесі жоғарылайды, газ ағыны үшін тоқырау аймақтары жойылады, адсорбенттің бірлік көлемінің адсорбциялық қабілеті артады. Мұның бәрі жылу мен масса алмасудың тиімді процесіне, адсорбердің көлденең қимасында газ ағынының біркелкі таралуына әкеледі. Ғылыми жаңалығы. Жүргізілген зерттеулер нәтижесінде ағын динамикасының елеулі өзгерістеріне әкелетін гидравликалық кедергінің есептелген тәуелділігі алынды. Газ ағынының турбуленттігінің адсорбциялық процестерге әсері адсорберлердің жұмысын оңтайландыру және олардың тиімділігін арттырудың маңызды аспектісі болып табылады. Практикалық құндылық. Зерттеу нәтижелерін тиімді адсорберлерді әзірлеу үшін пайдалануға болады, бұл пайдалану шығындарды азайтуға және өнімділікті арттыруға әкеледі. Есептеулер процестің жалпы тиімділігін арттыруға, ағынның таралуын жақсартуға, адсорбция жылдамдығын арттыруға, адсорбентті пайдалануды оңтайландыруға және өңдеу уақытын қысқартуға мүмкіндік береді.

Түйін сөздер: адсорбер, процесс, жылу және масса алмасу аппараты, саптама, гидравликалық кедергі, газ.

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ГИДРАВЛИЧЕСКОЕ СОПРОТИВЛЕНИЕ АДСОРБЕРА С РЕГУЛЯРНОЙ НАСАДКОЙ

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Аннотация. ААппараты адсорбционного типа широко применяются для осушки и очистки природного газа. Процесс адсорбции происходит эффективно, если будет поверхность контакта газовой и жидкой фаз больше. В связи с этим применяются адсорбенты из высокопористых материалов. Рассмотрено гидравлическое сопротивление адсорбера с регулярной насадкой. Определены основные особенности работы этой насадки. Установлены уменьшение порозности насадки и увеличение длины пути движения потока газа по сравнению с неподвижным слоем адсорбента. Эти особенности насадки учтены при выводе уравнений для определения гидравлического сопротивления адсорбера с регулярной насадкой. Оценены тепломасообменные характеристики регулярной насадки. Результаты. Расчеты гидравлического сопротивления адсорбера с регулярной насадкой показывают, что порозность регулярной насадки снижается на 3%, а длина пути движения газа и, соответственно, гидравлическое сопротивление слоя насадки увеличивается на 11,8% за счет наличия тел вращения в слое. Одновременно увеличивается степень турбилизации потока газа, устраняются застойные зоны для потока газа, увеличивается адсорбционная способность единицы объема адсорбента. Все это приводит к более эффективному процессу тепломассообмена, равномерному распределению потока газа в поперечном сечении адсорбера. Научная новизна. В результате проведенных исследований получена расчетная зависимость гидравлического сопротивления, которая приводит к значительным изменениям в динамике потока. Влияние турбулизации газового потока на адсорбционные процессы является важным аспектом для оптимизации работы адсорберов и повышения их эффективности. Практическая значимость. Результаты исследования могут быть использованы для разработки эффективных адсорберов, что приведет к снижению эксплуатационных затрат и увеличению производительности. Расчеты позволяют увеличить общую эффективность процесса, улучшают распределение потока, повышают скорость адсорбции, оптимизируют использование адсорбента, снижают время обработки.

Ключевые слова: адсорбер, процесс, тепломассообменный аппарат, насадка, гидравлическое сопротивление, газ.

Introduction. Adsorption-type devices are widely used for drying and purifying natural gas. The adsorption process occurs effectively if the contact surface of the gas and liquid phases is larger. In this regard, adsorbents made of highly porous materials are used. Adsorbents come in the form of grains of various diameters. The most common are zeolites. Adsorption devices can be periodic (vertical, horizontal, ring, etc.) or continuous. Each device has its own advantages and disadvantages. Their merits are assessed by the degree of purification of the substances. The design of adsorbers is selected based on the main characteristics of the medium to be dried (Kabibullin, et.el., 2023; Orymbetov, et.el., 2022; Sarilov, 2015; Shumetskiy, 2005).

At operating heat and mass transfer devices, in particular adsorbers, one of the main indicators of their operation is the hydraulic resistance of the contact (packed) layer. It determines the energy costs for carrying out the heat and mass transfer process, and accordingly, the economic efficiency of the entire technological process (Orymbetov, et.al. 2021; Sunil Jayant Kulkarni, 2016; Toth Jozsef, 2019).

Currently, there are many methods of capturing and neutralizing vapor and gaseous substances from the air. In practice, the following methods of gas purification are used: absorption, adsorption, catalytic, thermal, etc. Adsorption is a process that involves extracting polluting components from a gas mixture, which makes it possible to carry out deep cleaning of gases. Adsorption methods of separation and purification have found wide application in environmental protection, where other methods are not effective enough (Vetoshkin, 2006)

One of the ways to remove adsorbed pollutants is to completely replace the adsorbent with the waste material being sent to waste. This method is possible in cases where the amount of adsorbate is small or the replacement process is performed quite rarely (Keltsev, 1984).

Methods for calculating the hydraulic resistance of a dust collector are proposed, taking into account the resistance of the jet section, the filter partition, and the increase in resistance when dust accumulates in the granular layer (Samokhvalov, et.al., 2019).

Adsorbents used in exhaust gas cleaning systems must meet the following requirements: have high adsorption capacity when absorbing components at low concentrations in gas mixtures, have high selectivity, have high mechanical strength, have the ability to regenerate and have a low cost (Vetoshkin, 2006).

The object of the study is the investigation of hydraulic resistance in an adsorber with regular nozzle.

Materials and methods

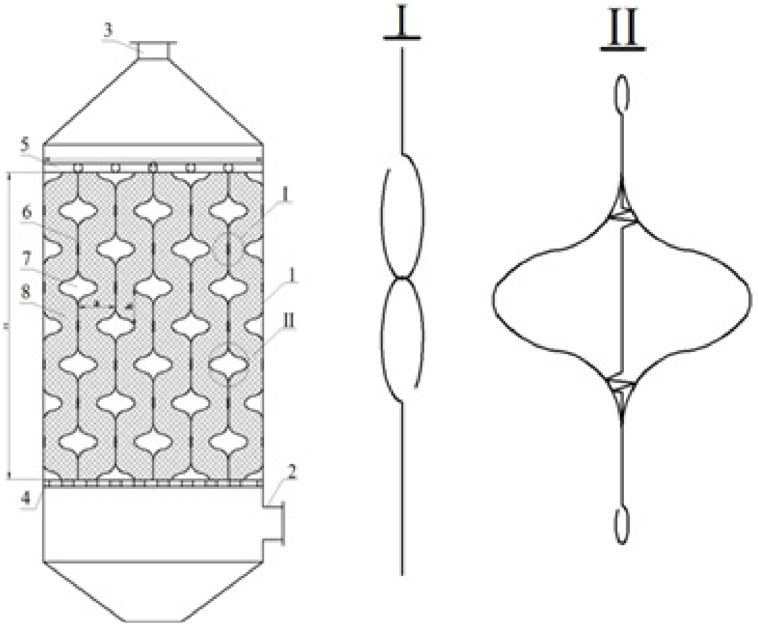
In work (Orymbetov, et.al, 2024), we developed a new adsorber with a regular packing (Fig. 1). It contains a cylindrical housing 1 with a lid and a bottom, interconnected by flanges, fittings 2 and 3, for the input and output of the purified gas or for the output and input of regeneration gas, respectively, lower and upper support grids 4 and 5, rotating bodies with sharp vertices top and bottom 7 with wire 6, with the help of which bodies of rotation are connected to each other vertically, as well as between the upper and lower support grids, adsorbent 8 loaded into zigzag channels formed between bodies of rotation with sharp tops suspended on wires. The bodies of revolution have equal height and width ranging from 40 to 80 mm. Moreover, adjacent bodies of rotation horizontally and vertically are shifted by the width and height of these bodies. Thus, these bodies of rotation inside the adsorber body form zigzag channels in which the adsorbent is laid. The bodies of rotation are suspended on vertical wires that come out of them and are connected to each other by hooks. The wires at the top and bottom of the nozzle are attached to the support grids.

The adsorbent layer in the adsorber is in a stationary state. Then the flow of adsorbed gas penetrates the adsorbent layer with ascending (descending) small flows.

The hydraulic resistance of such a packed layer, based on the internal problem of hydrodynamics, can be defined as pressure loss due to friction in pipelines

$$\Delta P = \lambda \frac{H \cdot a \cdot \rho_g \cdot w_g^2}{8 \cdot \varepsilon^3}; \qquad (1)$$

where λ - overall resistance coefficient, taking into account frictional resistance and local resistance that arises when gas moves inside curved channels formed by voids and pores between the elements of the packed layer and the flow around individual elements of the layer; H – height of the packed layer, m; a – specific surface area of packed elements, m^2/m^3; ρ_g – gas density, kg/m^3; w_g – average gas velocity over the cross section of the packed layer, m/s; ε – porosity of packed layer



1 – housing; 2,3 - ittings for input and output of purified gas or for output and input of regeneration gas, respectively; 4,5 - support grids; 6 – wires with the help of which bodies of rotation are connected to each other vertically, also between the upper support grid and lower support grid; 7 - bodies of revolution with sharp vertices up and down; 8 – adsorbent.
Figure 1. Adsorber with regular nozzle.

The resistance coefficient λ can be expressed by the two-term formula (Aerov, et.al., 1979)

$$\lambda = \frac{a'}{Re_d} + a'', \qquad (2)$$

where $a', a'' -$ constants, which are determined by processing experimental data. The first term of equation (2) determines the resistance in the laminar region of the gas flow, and the second term of equation (2) determines the resistance in the turbulent region of the gas flow. The Reynolds criterion in equation (2) is determined through the diameter of a ball from the same surface as the middle particle of the layer.

Based on the processing of extensive experimental data from various authors on the hydraulic resistance of a stationary granular layer, Ergan's two-term formula was obtained (Ergun, et.al., 1949)

$$\frac{\Delta P}{H} = 150 \cdot \frac{(1-\varepsilon)^2}{\varepsilon^3} \cdot \frac{g \cdot w_g}{d^2} + 1.75 \cdot \frac{(1-\varepsilon)}{\varepsilon^3} \cdot \frac{\rho_g \cdot w_g^2}{d}. \quad (3)$$

Ergan's formula can be reduced to the form of the equation (2)

$$\lambda = \frac{33.36}{Re_d} + 0.58 \,. \quad (4)$$

Results and Discussion

In our case, the gas flow moves through the tortuous channels of the adsorbent layer and at the same time through zigzag channels formed by bodies of rotation. Therefore, we introduce two amendments to Ergan's formula (3): 1) the porosity of the packed layer decreases due to the presence of bodies of rotation in the adsorbent layer; 2) due to the presence of bodies of rotation in the adsorbent layer, the adsorbed gas moves along a zigzag channel.

To calculate the porosity of an adsorber with a regular nozzle, we take into account the volume of bodies of revolution. As a first approximation, we assume that the body of rotation is formed from two cone-shaped bodies connected by their bases. Their curvilinear generators are described by a quadratic equation of the form

$$y = 0.1x + 0.88x^2.$$

Then the volume of the body of revolution is equal to

$$V_r = 2\pi \int_0^{0.08} (0.1x + 0.88x^2)^2 dx = 25.26 \cdot 10^{-6} \text{ м}^3.$$

Regular nozzle volume

$$V_{nz} = \frac{\pi D^2}{4} \cdot H = \frac{3.14 \cdot 0.72^2}{4} \cdot 4.8 = 1.97 \text{ м}^3.$$

Volume of bodies of rotation

$$V = V_r \cdot n \cdot b = 25.26 \cdot 10^{-6} \cdot 76 \cdot 30 = 0.0576 \text{ м}^3.$$

where n = 76 – number of bodies of rotation in one row; b = 30 – number of rows of bodies of rotation in the nozzle layer. Volume occupied by the adsorbent

$$V_{ads} = V_{nz} - V = 1.97 - 0.0576 = 1.91 \text{ м}^3.$$

Let us take the porosity of the adsorbent ε = 0.4, then the porosity of the adsorber with regular nozzle will be

$$\varepsilon_{nz} = \frac{V_{ads} \cdot \varepsilon}{V_{nz}} = \frac{1.91 \cdot 0.4}{1.97} = 0.388 \tag{5}$$

In the calculations it was assumed that the height of the regular nozzle H = 4.8 м, nozzle layer diameter D = 0.72 м, dimensions body of rotation: height h = 0.16 м, diameter d = 0.08 м.

In our regular packing, due to the movement of the adsorbed gas through zigzag channels, the path length of the processed gas increases. This can be determined from the following considerations. The bodies of revolution in the adsorbent layer are arranged in a checkerboard pattern (Fig. 1). The gas trajectory deviates from the vertical by half the width of the body of rotation and moves along an inclined line to the height of the body of rotation. Thus, the gas trajectory passes along the hypotenuse of triangle c (Fig. 2) on each row of bodies of revolution, i.e.

$$\text{c} = \sqrt{a^2 + a^2/4} = \text{a}\sqrt{5}/2. \tag{6}$$

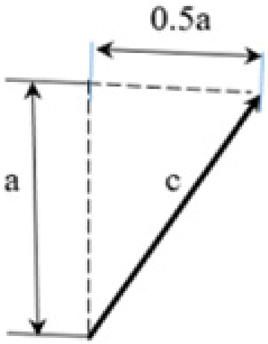


Figure 2. Gas trajectory

The increase in the path of gas movement is in a regular nozzle.

$$\frac{\text{H}_{ch}}{\text{H}} = \frac{\text{c}}{\text{a}} = \frac{\text{a}\sqrt{5}}{2\text{a}} = 1.118$$

where H_{ch} - length of zigzag channels in a regular nozzle.

Taking into account the amendments given above, we write Ergan's formula (3) for determining the hydraulic resistance of a regular nozzle (Fig. 1) in the following form: decreases

$$\frac{\Delta P}{1.118 \cdot H} = 150 \cdot \frac{(1-\varepsilon_{nz})^2}{\varepsilon_{nz}^3} \cdot \frac{\mu_g \cdot s_g}{d^2} + 1.75 \cdot \frac{(1-\varepsilon_{nz})^2}{\varepsilon_{nz}^3} \cdot \frac{\rho_g \cdot w_g^2}{d}, \qquad (7)$$

where $d = \sqrt[3]{\frac{6 \cdot V_3}{\pi}}$ – diameter of equivalent ball with nozzle particle;

V_3– volume of nozzle particle (adsorbent).

Calculations of the hydraulic resistance of an adsorber with a regular packing show that the porosity of a regular packing is reduced by 3%, and the length of the gas movement path and, accordingly, the hydraulic resistance of the packing layer increases by 11.8% due to the presence of bodies of rotation in the layer. This is due to the zigzag movement of gas in a layer of regular packing.

Conclusions: As a result of the conducted research, a calculated dependence of hydraulic resistance was obtained, which leads to significant changes in the flow dynamics. At the same time, the degree of gas flow turbulence increases, stagnant zones of the gas flow are eliminated, and the adsorption capacity of a unit volume of the adsorbent increases. All this leads to a more efficient heat and mass exchange process, uniform distribution of the gas flow across the adsorber cross-section. The obtained calculations allow increasing the overall efficiency of the process, improving flow distribution, increasing the adsorption rate, optimizing the use of the adsorbent, and reducing the processing time.

References

Aerov M.E., Todes O.M., Narinsky D.A. Devices with a stationary granular layer: Hydraulic and thermal calculation principles [Apparaty so statsionarnym zernistym sloyem: Gidravlicheskiye i teplovyye osnovy rascheta]. – L.: Chemistry, 1979. – 176 p. (In Russian)

Vetoshkin A.G. Gas cleaning process and equipment. [Protsessy i apparaty gazoochistki] Study guide. Penza: Izd-vo PGU, 2006. - 201 p. (In Russian)

Ergun S., Orning A.A. Fluid Flow Through Randomly Packed Columns and Fluidized Beds.– Ind. Eng. Chem., 1949, v.41, 1179 p. (in Eng.)

Kabibullin M., Orazbayeva K., Makhatova V., Utenova B., Kodanova Sh. (2023) REFORMING UNIT OPERATION CONTROL IN OIL AND GAS REFINING TECHNOLOGY. NEWS of the National Academy of Sciences of the Republic of Kazakhstan. Volume 1, Number 457, -P. 113-129 (in Eng.)

Keltsev N.V. Fundamentals of adsorption technology. [Osnovy adsorbtsionnoy tekhniki] 2nd ed., revised and enlarged. - M. Chemistry, 1984.- 592 p. (In Russian)

Orymbetov E., Orymbetova G.E., Khussanov A.E., Orymbetov T.E., Orymbetov B.E. Sectioning of petroleum gas adsorption drying. News of the National Academy of Sciences of the Republic of Kazakhstan. Volume 3, N 453 (2022), –P.155-165. (in Eng.)

Orymbetov T.E., Orymbetov E., Khusanov A.E. (2021) Analysis of the work of the unit for adsorption drying of petroleum gas at the Kenlyk field. [Analiz raboty uzla adsorbtsionnoy osushki neftyanogo gaza na mestorozhdenii Kenlyk] Proceedings of the international scientific and practical conference "Auezov readings - 19: 30 years of independence of Kazakhstan." Shymkent. 7:295-297. (In Russian).

Orymbetov B.E., Orymbetov E., Orymbetova G.E., Khusanov A.E., Orymbetov T.E. (2024) Adsorber. Utility model patent [Adsorber. Patent na poleznuyu model] No. 8833 dated 02.09.2024 (In Russian)

Samokhvalov N.M., Vinogradov V.V., Zykova Yu.A.. Cleaning efficiency and hydraulic resistance of a jet-filtration dust collector. [Effektivnost' ochistki i gidravlicheskoye soprotivleniye struyno-fil'tratsionnogo pyleulovitelya]. News of universities. Applied chemistry and biotechnology. Vol. 9. N 4. – P.759-767. 2019 (In Russian)

Sarilov M.Yu. Machines and apparatus for mass transfer processes: textbook [Mashiny i apparaty massoobmennykh protsessov: uch.posobiye] / M.Yu.Sarilov, P.M.Tyagushchev. – Komsomolsk on Amur: FSBEI HPE "KnAGTU", 2015. – 52 p. (In Russian)

Sunil Jayant Kulkarni (2016). Role of Adsorption in Petroleum Industries and Refineries. International Journal of Petroleum and Petrochemical Engineering (IJPPE), 2: –P. 16-19. DOI: http://dx.doi.org/10.20431/2454-7980.0201004. (in Eng.)

Shumetskiy Yu.I. (2005) Adsorption Processes [Adsorbtsionnyye protsessy]. Moscow. 164 p. (In Russian).

Toth Jozsef (2019). Adsorption. CRC Press, 904 p. USA. ISBN: 9780367447069 (in Eng.)

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