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Faculty "Chemical - technology"

The department of "Technology of the Oilchemical Industry"

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Dean of faculty of «ChT» dots. Ataullayev Sh. N. _____ Registration number No. ___ "__" _____ 2016	Head of department of «TOCHI» dots. Bozorov G.R. _____ "___" _____ 2016

GRADUATE QUALIFICATION WORK

Theme: The adsorptive purification of natural gas from sulfur compounds, technical and economic rates of a zeolitic way of natural gas purification

HAS EXECUTED: **student of group 1-12 NGKST Kholov Rustam**

HEAD: **Murodov M.N.**

CONSULTANT: **Tsukanov M.N.**

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MINISTRY OF THE HIGHEST AND AVERAGE VOCATIONAL EDUCATION OF THE REPUBLIC OF UZBEKISTAN
BUKHARA ENGINEERING INSTITUTE OF TECHNOLOGY
Department: "Technology of oilchemical industry"
Final qualifying graduate work

Student of group 1-12 Oil -gazchemical industry tecnology
Kholov Rustam Valerevich

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INTRODUCTION.

1. TECHNICAL PART

1.1. Theoretical bases of the adsorptive methods of cleaning
1.2. Process classification, main definitions
1.3. Main industrial adsorbents and their properties
1.4. Chemical adsorption

2. TECHNOLOGY PART

2.1. The equipment implementing adsorption process
2.2. Process of a desorption at Adsorption
2.3. Adsorption with a motionless layer of adsorbent
2.4. The description of laboratory installation of the adsorptive gas treatment from acid impurity zeolites

3. RATED PART

3.1. Calculation of an adsorber and the adsorptive purification unit of gases from acid components

4. HEALTH AND SAFE ACTIVITY PART

4.1. Labor protection.
4.2. Environmental protection.
4.3. Requirements for safety measures.

5. GRAPHIC PART

5.1Adsorber of axial type with a motionless layer of adsorbent
5.2 Adsorbers with a moving bed of adsorbent
5.3 Adsorber of radial type with a motionless layer of adsorbent
5.4 Adsorber with a moving bed of adsorbent for division of gases

Dean of faculty of "ChT":	dots. Ataullayev Sh. N.
Head of department of "TOCHI" :	dots. Bozorov G.R.
Head of foregn languages department	Kuvondikova H.B.
Head:	Tsukanov M.N.
Graduate:	Kholov R.V.

CONTENT **p.p.**

INTRODUCTION.

1. TECHNICAL PART

1.1. Theoretical bases of the adsorptive methods of cleaning……

1.2. Process classification, main definitions……..

1.3. Main industrial adsorbents and their properties…….

1.4. Chemical adsorption……..

2. TECHNOLOGY PART

2.1. The equipment implementing adsorption process……

2.2. Process of a desorption at Adsorption……..

2.3. Adsorption with a motionless layer of adsorbent……

2.4. The description of laboratory installation of the adsorptive gas treatment from acid impurity zeolites ……

3. RATED PART

3.1. Calculation of an adsorber and the adsorptive purification unit of gases from acid components…….

4. HEALTH AND SAFETY

4.1. Labor protection……..

4.2. Environmental protection……

4.3. Requirements for safety measures……...

5. GRAPHIC PART

CONCLUSIONS…….

THE LIST OF THE USED LITERATURES…….

Introduction.

The report of the President of the Republic of Uzbekistan Islam Karimov on the enlarged meeting of the Cabinet devoted to results of social and economic development of the country in 2015 and to the most important priority directions of the economic program for 2016.

In the agenda of enlarged meeting of the Cabinet - results of economic and social development of the country for the expired 2015 and the statement of the major priorities of development of national economy for 2016.

Analyzing progressive advance of the country on the way of democratic transformations and a sustainable development, we have all bases to declare that in the expired year the plunge in implementation of essentially important reforms directed on achievement of our main goal is taken - to reach the level of the developed democratic states of the world with the strong socially oriented economy providing the worthy level and quality of life of our people.

The speech, first of all, goes about implementation of comprehensively thought over Program aimed at providing deep structural transformations, reliable protection of interests of private business and small business and that is essentially important, - in legislative, normative legal and practical as it is provided in our Constitution, providing a priority role of a private property, progressive reduction of presence of the state at economy of Uzbekistan.

It is recognized reasonable at this stage of our development under a direct control of the state to keep only the enterprises which are carrying out production and processing of a hydrocarbonic raw material, precious and non-ferrous metals, uranium, and also the strategic infrastructure industries of natural monopolies - iron and highways, air transportation, generation of the electric power, electric and utility networks.

The task has been set and conditions for bulk selling of the state assets, first of all to foreign investors are created. So, at "zero" redemption cost about 22 thousand new workplaces have been implemented on a competitive basis to new investors

of 506 property complexes with adoption of investment obligations by investors of about 1 trillion sum and 40 million US dollars, and also creation.

Among the objects put into operation especially would like to note the Ustyurtsky gas-chemical complex constructed together with South Korean investors and specialists on the basis of a field Surgil. This complex worth over 4 billion dollars is one of the most modern hi-tech and large productions in the world. Its commissioning will allow to receive annually 83 thousand tons of polypropylene which was imported to the republic before, to increase polyethylene output by 3,1 times, to employ more than 1 thousand highly qualified specialists.

Defining the main priorities of social and economic development of our country for 2016, we cannot but consider the serious problems arising in connection with the proceeding global crisis, sharp reduction of demand, uncertainty and essential the increased fierce competition in the world markets the falling of growth rates of production and all effects following from here which have concerned the majority of the states in the world.

In this regard the difficult problems facing us in 2016 dictate need of full refusal of the become obsolete methods of inertial forecasting from the reached level, relying on average values of development.

Continuous technology and technical updating of production, and also continuous search of internal reserves, implementation of deep structural transformations in economy, modernization and diversification of the industry should be the main reference point for us.

In other words, time demands to pass to consecutive 3-4-phasic cycles of processing of raw materials into products demanded in the world market according to the scheme: basic raw materials - primary processing (semi-finished products) - ready materials for industrial production - finished goods for final consumption.

Thus there is a need during the developing and implementation of programs to trace a full cycle of deep processing by each type of primary raw material - a semi-finished product up to finished goods of final consumption.

In a word, it is necessary to provide forecasting of all cycle of the organization of production - from raw materials to finished goods with justification of expediency and an economic return.

As show calculations, as a result of production with a high value added production of petrochemical products can be increased with development of its new types by 2030 by 3,2 times, products from non-ferrous metals - by 2,2 times, from ferrous metals - by 2,3 time, products of chemical industry, including mineral fertilizers, - by 3,2 times.

Along with it increase in production of modern finished goods with the high value added demanded in foreign markets will become a basis of steadily high growth rates of its export.

It is necessary to tell that this work in the country is already begun. However she demands cardinally new program integrated approach on each perspective view of raw materials and the semi-finished products possessing high potential to have the specific program of deep processing calculated on 2020, 2025, 2030.

We have all bases, proceeding from the deep analysis of tendencies of development of world economy, a real assessment of our resources and opportunities today, to set for themselves the target task - not less than twice to increase the volume of gross domestic product of our country by 2030.

1. Technical part

1.1. Theoretical bases of the adsorptive methods of cleaning

The adsorptive methods of purification of gases are based on the selection extraction of acid components by firm absorbers - adsorbents. In that case when the taken component is kept by adsorbent only physical forces, *physical adsorption* takes place. If the taken component enters with adsorbent chemical interaction speak about *chemical adsorption.*

Effective adsorbents of carbon dioxide -*zeolites.* Molecules of carbon dioxide are quite small. Their diameter makes about 0,31 nanometers (3,1 Å) that allows them to get into internal structure of the majority of zeolites. Most often for adsorption use SAA zeolite. Together with carbon dioxide zeolites absorb also water vapors. Therefore along with purification of gases of carbon dioxide there is their osushka. The desorption of the absorbed components is carried out pressure reduction and temperature increase.

The adsorptive methods of cleaning

Methods of purification of gases of hydrogen sulfide with use of firm sorbents can be classified on the basis of the physical and chemical processes happening at sorption of sulphurous connections:

- the adsorptive methods (physical adsorption);
- hemosorbtsionny methods (formation of steady chemical compounds of hydrogen sulfide with a sorbent).

Physical adsorption

The method is based on ability of some solid bodies selectively to absorb gaseous components from gas mixes. The molecules of the contaminated gas or steam which are present at gas mix gather for surfaces or in a time of solid material. The substance absorbed from a gas phase - is called adsorbtivy, and the strong substance, on a surface or which time occurs adsorption of the absorbed substance - adsorbent. A gas phase in which there is a taken component - carrier gas and after the taken component has passed into the adsorbed state, it is called an adsorbate.

Apply in this case:

- when other methods are inefficient;
- concentration of the contaminating substances is very small and the guaranteed recuperation of the extracted impurity because of its considerable cost or danger is required. Delete with an adsorption method SO2, hydrocarbons, chlorine, hydrogen sulfide, carbon sulfur from off-gases, and others.

The phenomenon of adsorption is caused by availability of attractive forces between molecules of adsorbent and an adsorbtiv on limit of the section of the adjoining phases. Transition of molecules of the contaminating substances on a surface layer of adsorbent comes from carrier gas if attractive forces of adsorbent more attractive forces operating on adsorbtiv from molecules of carrier gas. Molecules of the adsorbed substance, passing to an adsorbent surface, reduce its

energy therefore there is a warmth allocation, about 60 kJ/mol (small). Attractive forces are had the different - physical or chemical and, therefore, distinguished:

Physical adsorption - at which interactions of molecules of the contaminating substances decides on a surface of adsorbent by weak disperse, induction forces (forces Wang - der - Valls). Thus the adsorbed molecules do not enter chemical interaction with molecules of adsorbent and keep the identity.

For physical adsorption the high speed of process, small durability of communication and small warmth is characteristic. With temperature increase the amount of physically adsorbed substance decreases, and pressure increment to increase of size of adsorption. Advantage - easy reversibility of process in the way:

a) reduction of pressure

b) increases in temperature.

The adsorbed molecules easily are desorbed without change of chemical composition, and the regenerated adsorbent can be reused. Process can be conducted cyclically, alternating a stage of absorption and allocation of the taken component.

Chemical adsorption - is the cornerstone chemical interaction between adsorbent and the adsorbed substance. Forces operating thus much more, and the released heat matches heat of chemical reaction and makes 20 - 400 kJ/mol.

Main differences:

1) molecules of an adsorbtiv, having easily entered chemical interaction, strongly keep on a surface and in an adsorbent time;

2) reaction speed, at low temperatures is small, but increases with growth of temperature.

Both types of adsorption accompany each other, however, for purification of gases physical adsorption has the greatest value.

Adsorption call process of absorption of substance of mix of gases, vapors or solutions a surface or volume of a time of a solid body - adsorbent.

The phenomenon of adsorption is known long ago. Such natural materials as sand and the soil, used for water purification at a dawn of human society. At the end of the XVIII century K. Sheele and at the same time Fontana have found ability of svezheprokalenny charcoal to absorb different gases in the volumes several times exceeding its own volume. Soon it has become clear that the size of the absorbed volume depends on type of coal and the nature of gas. T.E. Lovits in 1785 has opened the adsorption phenomenon coal in the liquid environment, in detail investigated it and has suggested to use coal for cleaning of pharmaceutical preparations, alcohol, wine, organic compounds. Lovits has shown that charcoal is capable to clear quickly spoiled water and to do it suitable for drink. And now as the main operating beginning of water filters carbon materials, of course more modern, than natural coals serve. Adsorption of toxic agents from air has been used by N.D. Zelinsky at creation of a gas mask during World War I.

Adsorption of gases on solid surfaces is used in some industries of the food industry, namely oil and fat (for example, in production of margarine) and in

fermentative (for example, in production of yeast) for cleaning of technology gas streams for the purpose of prevention of emissions of harmful substances in the atmosphere. Absorption of vapors of water happens on porous substances which carry out a role of solid adsorbent. Similar processes are observed concerning sugar, salt and crackers. The adsorptive way of regulation of gas structure of storages of perishable goods allows to reduce several times losses and to increase storage lives. Adsorption of different food acids, lemon in particular, reduces a surface tension of the majority of soft drinks in comparison with water. Adsorption of substances on an interface liquid - gas promotes stability of foams. Similar process takes place in the fermentative industry by production of yeast and some other semi-products. Wetting strengthening by water of different surfaces is widely used in the industry as the accompanying process during the washing of the equipment, preparation of raw materials, processing of semi-finished products, etc. Adsorption on border a solid body - liquid is widely applied at purification of liquids (for example, diffusion juice by production of sugar, vegetable oils and juice) from impurity.

Development of the theory of the adsorptive forces has not reached such stage when on known physical and chemical properties of gas and a solid body it would be possible to calculate an adsorption isotherm yet, without conducting pilot studies. Therefore to attempts to describe experimental isotherms by means of the different theoretical equations to which there correspond certain models of adsorption, the huge number of works is devoted. If the theoretical equation of an isotherm of adsorption well reproduces experimental data, it is possible to calculate unknown sizes of adsorption under different conditions (r and T) and to determine different geometrical parameters of solid bodies. Let's consider only the few, most widespread theoretical equations of isotherms of adsorption.

1.2. Process classification, main definitions

Basic concepts of process of adsorption

Spontaneously proceeding diffusion process of interaction of two phases - a solid body - adsorbent and gas, steam or the dissolved substance - an adsorbtiv, occurring absorption of gas, couple or the dissolved substance a surface of a solid body is called as adsorption.

Absorption of gases, vapors and the dissolved substances solid bodies usually is followed by processes of penetration of the absorbed substance into a solid body (absorption), capillary condensation and chemical reactions (chemisorption) that very complicates studying actually of adsorption. Therefore absorption of gases, vapors and the dissolved substances solid bodies usually is considered as the general process of sorption.

Adsorption is always followed by heat production. In most cases the thermal effect of adsorption in the size comes nearer to warmth of condensation of the absorbed gas or couple.

Adsorption is subdivided into two look: physical and chemical. Physical adsorption is generally caused by surface vandervalsovy forces which are shown at the distances considerably exceeding the sizes of the adsorbed molecules therefore on an adsorbent surface some layers of molecules of an adsorbate usually keep.

At chemical adsorption the absorbed substance enters chemical interaction with adsorbent with education on its surface of normal chemical compounds.

Attractive forces arise on an adsorbent surface thanks to that the force field of surface atoms and molecules is not counterbalanced by forces of interaction of the next particles. By the physical nature of force of interaction of molecules of the absorbed substance and adsorbent belong generally to dispersive, arising thanks to movement of electrons in the approaching molecules. In some cases adsorptions great value have electrostatic and induction forces, and also hydrogen bonds. Therefore adsorption is spontaneous process which current is followed by reduction of free energy and entropy of system.

Processes of adsorption are selective and reversible. Process, the return adsorptions, call a desorption which use for allocation of the absorbed substances and regeneration of adsorbent.

It is most rational to apply adsorption to processing of mixes with low concentration of the drawn substances.

Static and dynamic activity of adsorbents.

The main characteristic of adsorbent is its activity determined by weight amount of the substance absorbed by unit of volume or absorber weight.

Distinguish activity static and dynamic.

Static activity of adsorbent is characterized by the maximum quantity of the substance adsorbed by the time of achievement of balance by weight or volume unit of adsorbent at this temperature and concentration of the adsorbed substance in gas-air mixture.

Dynamic activity is the characteristic of adsorbent at course of vapor-air mixture through an adsorbent layer until a skip of the adsorbed gas.

If gas mix passes through an adsorbent layer, in an initial stage of process adsorbtiv is completely extracted from gas mix. After a certain period in the gas mix leaving an absorber noticeable, escalating quantities of an adsorbtiv (skip) start appearing, and by the end of process concentration of the leaving gas becomes equal initial concentration of vapor-air mixture.

In adsorbers of industrial type with absorbent carbon dynamic activity makes 85-95% from static, and in case of use of silica gel dynamic activity is less static for 60-70%.

The selection properties of adsorbents.

In adsorption processes, as well as in absorption processes, the absorbing substances (adsorbents possess the selection properties in relation to the absorbed gases and vapors. In other words, application of the adsorptive processes as a method of division of gas mixes is based that the gas mix given to contact with adsorbent is exempted only from one component while others are unabsorbed.

If in absorption processes the selection qualities of process were defined by solubility or insolubility of gas in the absorbing liquid, in adsorption processes criterion of the selection qualities is static activity of adsorbent.

From mix of the gases given to contact with adsorbent, first of all and in much bigger quantity gas or steam of that substance which has more high temperature of boiling is absorbed. In most cases boiling temperature of the absorbed gas (for example, benzene vapors) strongly differs from boiling temperature of inert gas (for example, air) and presence of inert gas has almost no impact on the process course. In this case absorption of benzene from vapor-air mixture with partial elasticity of vapors of benzene r proceeds in the same way as absorption of the pure vapors of benzene having the same pressure.

Division by the adsorptive method of mix of gases which components have close lying boiling temperatures, provides great difficulties or it is almost impossible.

1.3. Main industrial adsorbents and their properties

The main industrial adsorbents are the porous bodies possessing large volume of micropores. Properties of adsorbents are defined by the nature of material of which they are made, and porous internal structure.

In industrial adsorbents the main amount of the absorbed substance is occluded on walls of micropores (r <109 m). A role of a transitional time (10-9 <r <10-7 m) and a macrotime (r <10-7 m) is generally reduced to transportation of the adsorbed substance to micropores.

Adsorbents are characterized by the absorption, or adsorptive capacity determined by the greatest possible absorbate concentration in unit of mass or the volume of adsorbent, its porous structure, the nature of the absorbed substance, its concentration, temperature, and for gases and vapors - from their partial pressure. Absorption ability of adsorbent greatest possible under existing conditions is called conditionally equilibrium activity.

On chemical composition all adsorbents can be separated on carbon and not carbon. Treat carbon adsorbents active (absorbent carbon), carbon fibrous materials, and also some types of solid fuel. Not carbon adsorbents include silica gels, active aluminum oxide, aluminogels, zeolites and clay rocks.

The active coals consisting of a set of randomly located graphite microcrystals usually use for absorption of organic substances in processes of cleaning and division of liquids and gases (vapors). These adsorbents receive dry distillation of a number of carbon-containing substances (wood, coal, bones of animals, stones of fruits, etc.). After that coal is activated, for example calcinate it at a temperature 850-900o With that leads to release of a time from resinous substances and formation of new micropores. Activation is carried out also extraction of pitches from a time organic solvents, oxidation by air oxygen, etc. More homogeneous structure of coals turns out at their activation by chemical methods: by their processing by hot solutions of salts (sulfates, nitrates, etc.) or mineral acids (sulfuric, nitric, etc.)

Quality of absorbent carbon depends on properties of initial carbon-containing materials and on activation conditions. The characteristic of extent of activation of absorbent carbon is obgar, i.e. the burned-down part of coal expressed percentage of amount of initial material.

Absorbent carbon is applied at adsorption either in the form of grains from 1 to 7 mm, or in the form of powder. Grains and powder are received by crushing and classification. The specific active surface of active coals is expressed from 600 to 1700 sq.m on one gram. Absorbent carbon mainly is applied to absorption of vapors of the organic liquids which are in gas mixes and to purification of different solutions of impurity.

Serious lack of these coals is combustibility, and it is possible to apply them at temperatures not over 200 °. For reduction of combustibility to them mix silica gel, however such additive leads to adsorbent decrease of the activity therefore absorbent carbon with a silica gel additive to them practically applies rather seldom.

Silica gel call a product of dehydration of the gel of silicic acid received by effect of sulfuric or hydrochloric acids or solutions of acid salts on sodium silicate solution. The dropped-out gel of silicic acid after washing is dried up at a temperature of 115-130 ° to humidity of 5-7%.

Silica gel differs in uniformity of a time as in size, and distribution. Silica gel in the form of grains with a diameter from 0,2 to 7 mm mainly is applied to absorption of vapors of water, i.e. to drying of gases. The specific active surface of silica gel is expressed about 600 sq.m on one gram.

Their incombustibility and big mechanical strength belong to advantages of silica gels. A shortcoming sharp decrease in absorption ability in relation to vapors of organic substances in the presence of moisture belongs.

On sorption properties silica gel is adjoined close by the aluminogels received by heat treatment of aluminum hydroxide at temperatures 600-1000os. A time of the received sorbent have diameter of 1-3 nanometers, a specific surface of 2·10 5 - 4·10 5 sq.m/kg; the bulk density of such sorbent is 1600 kg/m3. Alyumageli is used for an osushka of gases, by purifications of water solutions and mineral oils.

Zeolites represent natural or synthetic minerals which are the water aluminosilicates containing oxides of alkaline alkaline-earth metals. These adsorbents differ in regular structure of a time which sizes are commensurable with sizes of the absorbed molecules. Feature of zeolites consists that the adsorptive surfaces are connected among themselves by windows of a certain diameter through which only molecules of the smaller size can get. Division of mixes with molecules, different in the size, that has served as the reason to call zeolites molecular sets is based on it.

To division of gas mixes apply zeolites in the form of balls or granules from 1 to 5 mm in size, and to division of liquid mixes - in the form of fine-grained powder.

Especially widely zeolites use for a deep osushka of gases and liquids, in processes of cleaning and division of mixes of substances with a close molecular weight, and also in quality as catalysts and their carriers.

As adsorbents apply natural clay rocks to purification of liquids of different impurity. These clays for their activation process sulfuric or hlorovodorodny acids and receive adsorbent with a specific surface of a time about (1,0 ÷1,5) · 105 sq.m/kg.

Industrial adsorbents

Any solid body possesses a surface and, therefore, potentially is adsorbent.

In equipment use adsorbents with strongly developed inner surface received as a result of (agglomeration), synthesis and special processing.

Adsorbents should possess:

− big dynamic capacity (time of protective action);
− big specific surface;
− selectivity;
− thermal and mechanical stability;
− ability to regeneration;
− simplicity of production;
− low cost;

These are active coals, silica gels, zeolites, clay minerals, sintered glasses and others.

The adsorptive capacity of adsorbents (activity)

Determine the sizes of devices and efficiency of purification of gases by it.

Distinguish the static and dynamic capacity of adsorbent. Dimension [gram of the absorbed substance / on 100g. adsorbent or mol/g]

Static capacity shows, what amount of substance is capable to adsorb is capable to adsorb adsorbent in the conditions of balance.

Dynamic capacity corresponds the absorbed substance an adsorbent layer from the beginning of process prior to the beginning of "skip" of an adsorbtiv i.e. when in the carrier gas leaving an adsorbent layer there are traces of an adsorbtiv.

The adsorptive capacity depends: by nature substances it increases with increase in a surface, porosity, decrease in the sizes of a time. It increases: with increase of concentration of the contaminating substances carrier gas; pressure in system. With increase in temperature and humidity the adsorptive capacity decreases therefore before use they are dried up. Good adsorbent does not lose activity when performing hundreds and thousands of cycles.

The adsorptive purification of gases is most effective when processing large volumes of gases with the small content of impurity, for example, for thin purification of process gases of sulphurous connections and carbon dioxide, and also during removal of vapors of toxic agents and carcinogens. Application in need of reduction of the content of impurity to several million shares and even is most reasonable below, for example, the contaminating substances with a strong smell it is possible to find at the contents them in air about 100 billion-1 therefore it is required to lower concentration even below.

Efficiency of the adsorptive systems is defined, mainly, by properties of adsorbent which should:

−to have high adsorptive capacity;
−to have high selectivity;
−to have high mechanical strength;
−good to be regenerated;
−to have low cost.

Adsorbents subdivide into three groups:

1) unpolar strong substances on which surface there is a physical adsorption.

2) the polar - there is a chemical adsorption without change of structure of molecules of gas and a surface of adsorbent.

3) substances on which surface purely chemical adsorption proceeds and which desorb gas molecules after chemical reaction, thus their substitution is required.

The most widespread unpolar adsorbent - the absorbent carbon which is consisting of neutral atoms of one look and having a surface with uniform distribution of charges at the molecular level.

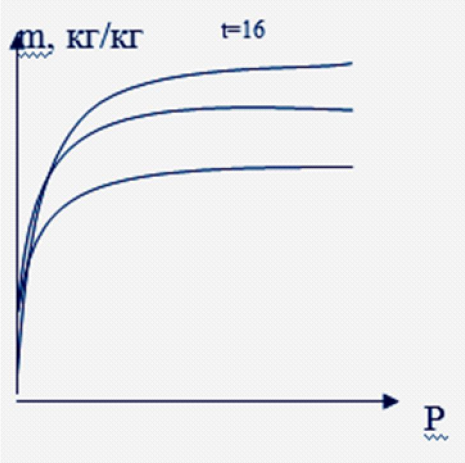
Let out:

1) for domestic ventilyation of AG, KAU, SKT. The size of granules is 1 - 6 mm, $\rho_н$=380 - 600 kg/m3.

2 recuperation ARES, ART coals, SKT - 3.

3) molekulyarno - screen MSC coals.

Pic.№1



The amount of gas of the adsorbed 1 g of adsorbent in an equilibrium state depends by nature adsorbent and an adsorbate, and also on temperature and pressure. Dependence of the weight (m) of the adsorbed contaminating substances on an adsorbate (absorbent carbon) at t=const.

The isotherm of adsorption shows that as adsorption - process exothermic, the amount of the substance adsorbed in an equilibrium state decreases with temperature increase.

Regeneration of adsorbent includes:

- desorption, drying, cooling

a) thermal (160 ÷ 170 °)

b) at high temperatures (300 - 400 °)

c) displacement (cold)

Characteristic of adsorbent

As adsorbents porous strong substances with the big specific surface which is usually carried to substance unit of mass are applied. Adsorbents have capillary channels, different on diameter, - a time which can be conditionally separated into a macrotime (more than 2-10 ~ 4mm), a transitional time (6-10 ~ 6-2-10 ~ 4mm), micropores (2-10 ~ 6-6 - 10 ~ vmm). Nature of process of adsorption is defined by the size of a time.

The specific surface of a macrotime is relatively very small therefore on their walls a minute quantity of substance is adsorbed. A macrotime plays a role only of transport channels for the adsorbed molecules.

On a surface of a transitional time which sizes usually considerably exceed the sizes of the adsorbed molecules, in the course of adsorption layers of the absorbed substance are formed. Formation of layers one thick a molecule (monomolecular adsorption) and in some molecules (polymolecular adsorption) is possible.

The sizes of micropores come nearer to the sizes of the adsorbed molecules and adsorption in micropores leads to filling of their volume. Thereof the assumption of formation of layers of the absorbed substance on a surface of micropores does not make physical sense. Usually micropores are crossed macro - and transitional couples that reduces the way passed by the adsorbed molecules and leads to adsorption acceleration.

In a bigtime with a diameter more than 2 - 10 ~ mm and a small time, comparable with a diameter of molecules of the absorbed substance, the phenomenon of capillary condensation is absent.

Adsorbents are characterized absorption, or the adsorptive, the ability determined by absorbate concentration in unit of mass or adsorbent volume.

Absorption ability of adsorbent in relation to this substance depends on temperature and pressure at which adsorption, and from concentration of the absorbed substance is made. Absorption ability of adsorbent greatest possible under existing conditions conditionally is called its equilibrium activity.

In the industry as absorbers apply mainly active coals and mineral adsorbents (silica gel, zeolites, etc.), and also synthetic ion exchange resins (ionites).

Active coals - sorbents of an organic origin (from coal, peat, wood materials, waste of paper production, a bone of animals, a shell of nuts, stones of fruits, etc.).

In the beginning initial material subject to heat treatment at t = 600 ÷ 900 °C, from coals moisture and pitches disappears, and then for giving of porosity it activate - process steam, gases or chemical reagents (CO, CO2, NH3, water vapor) at t = 800 ÷ 900 °C. Taking temperature, feed speed of the activator and time of activation, receive with the different it is adsorptive - structural properties of brand of active coals: BAU, DAK, ARE - And, ARE - B, ring road, SKT - 1,2.3,4. The main characteristic - ρнас, and fractional structure. Let out in the form of granules, with a diameter of 2 ÷ 5 mm, N ›diameter. Sometimes they are split up for smaller fractions 0,15 ÷ 2,5 of mm, applied to gas purification with the stationary movement and a layer of adsorbent.

Powdery dfr coals <0,15 mm - for cleaning of substances in a fluid phase. BAU - Berezovsky active coal, AG - the granulated active coal, ARE - active coal recuperation. KAU - stone, SKT - coal of sernistokaliyevy activation.

(Ventilating) apply the AG, KAU brands to cleaning of gas emissions. SKT, and also coals from polymeric materials and molekulyarno - screen coals (MSC) - possess high adsorptive activity in the field of small concentration of the contaminating substances differing in the increased durability, so SAU - (make of uranium polymer).

Negative properties - combustibility, are oxidized at t = 250 °C to reduce fire danger, to coal add silica gels.

High-porous active coals receive by dry distillation of different carbon-containing substances (a tree, bones, etc.) and activations of the received coals for increase of their porosity. Activation is carried out calcinating of coal at temperatures of 900 °C, and also other ways, for example removal from a time of coal, pitches and some other products of dry distillation by their extraction by organic solvents, oxidation by air oxygen, etc. For increase of activity of coals often before a carbonization enter the activating additives into them (solutions of chloride zinc, acids, alkalis, etc.).

The specific surface of active coals fluctuates from 600 to 1700 m2g.

The size of granules of some standard brands of active coals for adsorption of gases and vapors makes 1-5 mm (BAU coal) and 1,5-2,7 mm (SKT coal). The bulk density of coals of these brands is equal 350 and 380-450 g / ж3 respectively. Use of coals of this or that look depends on a kind of process of adsorption in which they are used (absorption of gases, recuperation of flying solvents etc.).

Active coals absorb vapors of organic substances, than waters better, however with increase of moisture content in active coals their ability to absorb vapors of organic substances decreases. They are applied usually to recuperation of flying solvents. A lack of active coals is their combustibility.

Silica gels. These adsorbents represent the products of dehydration of gel of silicic acid received by processing of solution of sodium silicate (soluble glass) by mineral acids or acid solutions of their salts. The specific surface of silica gels changes from 400 to 770 sq.m/g. The size of granules fluctuates from 0,2 to 7 mm, bulk density makes 100-800 kg/m3.

Silica gels are applied mainly to an osushka of gases. Absorption ability of silica gels in relation to vapors of organic substances strongly decreases in prisutstviivlag. The advantage of silica gels is their incombustibility and big mechanical strength, than at active coals.

Silica gels - hydrated amorphous, received by interaction of liquid glass and sulphuric acid. It is mineral adsorbent, reaction product ($SiO2 \cdot n\ H2O$) dfr = 0,2 ÷ 7 mm in the form of grains,

$\rho_{нас}$ = 0,2 ÷ 7g/sm3.

The cheap sorbent, has high mechanical strength to abrasion, the low temperature of regeneration (110-120 °C), apply to an osushka of gases and catching of the organic contaminating substances.

The silica gel received in the acid environment and which is washed out by the acidified water - possesses a small time. In the alkaline environment - open.

Depending on a grain form:

− kuskovy silica gel (grain of the wrong form);

− granulated (grains of a spherical or oval form).

The recommended particle size distribution of silica gels for different ways of purification of gases

— for processes with the boiling layer - 0,1 ÷ 0,25 mm
— with a moving bed - 0,5 ÷ 2,0mm
— with a stationary layer - 2,0 ÷ 7,0mm

Shortcoming - destruction of grains under the influence of drop moisture

Aluminogels - Al2O3 nH2O - active aluminum oxides, as well as silica gels are hydrophilic adsorbents, they possess the developed structure, a big surface and are acceptable for an osushka of gases, catching of hydrocarbons and fluorine. They are more firm to effect of water. They are capable to absorb from 4 to 10% of water vapors of own weight.

Zeolites (about the Greek boiling stones). Everything above the considered adsorbents have irregular structure therefore during their time the most different molecules by the sizes can get and keep, i.e. they do not possess selective adsorption is their shortcoming.

Selectively adsorb a molecule, identical by the size, adsorbents with strictly regular porous structure can are natural minerals siderite, fozhazit, erionit, glabazit, mordenit, etc. By heat treatment they are turned the adsorbent possessing high porosity, a big surface and the identical sizes of a time. It is not enough natural zeolites in the nature, they are contaminated by impurity therefore for industrial application about 100 names of zeolites are synthesized.

Zeolites of the KA, NaA brands, SAA, NAH, SAKHA are most applicable. The first letter corresponds to the cation compensating a grid charge (To +, Na +, Sa +), the second - type of a crystal grid.

Zeolites - the unique adsorbents extracting ammonia, SO2, acetylene, H2S, CO2, etc.

These adsorbents represent natural or synthetic minerals which are water aluminosilicates of cations of elements of the first and second groups of periodic system of D. I. Mendeleyev. As industrial adsorbents mainly artificial (synthetic) zeolites are applied. Relatively recently the zeolites possessing very homogeneous structure of a time which sizes are commensurable with sizes of the adsorbed molecules have been received. These zeolites show molekulyarno screen action which consists in their ability not to absorb a molecule which diameter is more than diameter of a time. Molecular and screen properties also some natural zeolites possess, for example natrolit. Molecular and screen effect of zeolites is used often in industrial practice for division of some substances, for example normal and isoparaffin hydrocarbons.

Zeolites differ in high absorption ability in relation to water and are highly effective adsorbents for an osushka and purification of gases and liquids, in particular for a deep osushka of the gases containing small amounts of moisture. The size of granules of zeolites makes from 2 to 5 mm, Ionites. These adsorbents represent both natural, and synthetic inorganic and organic substances. Zeolites, clay minerals, fossil coals, etc. belong to natural ionites. Synthetic ionites are melted zeolites and molecular a sieve (zeolites with the correct crystal structure), ion exchange resins, the activated minerals and organic substances, etc.

Ionites are almost insoluble in water, and also in normal solvents and possess the mobile ions capable to exchange on equivalent quantity of ions (with a charge of the same sign) from solution of electrolyte with which the absorber interacts.

The ionites containing acid active groups and exchanging with electrolyte solution mobile anions are called as anion exchangers, and the ionites containing active main groups and exchanging mobile cations - cation exchangers. There are also amphoteric ionites capable to a cationic and anion exchange at the same time.

Typical reactions of an ionic exchange:

1. Reaction of an anion exchange

2. Reaction of a cationic exchange, and in both equations formulas of the substances making a firm phase are allocated.

The mechanism of an ionic exchange is caused by structure and properties of an ionite. So, for example, ionites with a crystal grid contain the ions withheld by electrostatic forces in its corners; under the influence of these forces also there is generally ionic exchange. Properties of many ionites are connected with their swelling capacity in water solutions; swelling usually is followed by very substantial increase of pressure.

Ion exchange resins possess the big exchange capacity, selectivity to separate ions, chemical firmness and mechanical strength. Therefore now they are the most widespread ionites which have almost forced out ionites of other types in industrial conditions.

Change of structure of active groups at synthesis of ion exchange resins, it is possible will receive ionites with very various properties.

Regeneration of adsorbents

Regeneration consists from its time of the adsorbed substance at a distance. Efficiency of process of cleaning depends on quality and the speed of allocation of the adsorbed substance from adsorbent.

Adsorption methods:

— thermal (temperature increase of a layer of adsorbent to 110 - 130 °C - at normal and 300 - 400 - the increased temperatures);

— a displacement desorption (at 30 - 80 °C);

— the desorption with a field of sharp water vapor is more widespread now.

1.4. Chemical adsorption

Hemosorbtsionny purification of gases of a serovodoro has started being used with the middle of the 19th eyelid for purification of lighting gas in England. It was first-ever hemosorbtsionny process of technology purification of gases. In this process as a chemisorbent absorption weight on the basis of natural raw materials - the marsh ore containing ferrous hydroxide was used. For a long time this way remained, almost, only process of purification of combustible gases of hydrogen sulfide, and was widely adopted in world practice. The way was continuously improved as on structure and methods of preparation of a chemisorbent, and on hardware registration.

However in process of increase in volumes of the recycled gases and involvement in processing of gases with a high hydrogen sulfide content, this process has been forced almost out from the industry by liquid cyclic and oxidizing methods of purification of gases. In recent years for purification of natural gas with a low hydrogen sulfide content the adsorptive processes with use of synthetic zeolites were widely adopted.

Along with traditional adsorbents develop absorbers on the basis of molybdenum oxides, tellurium, manganese and carbonates of alkaline metals which carry out not only physical adsorption, but also chemisorption in recent years.

Zinc oxides, gland, copper belong to the most widespread firm chemisorbents. When using iron oxides (the oldest way) reactions proceed:

$$Fe_2O_3 + 3H_2S \rightleftharpoons Fe_2S_3 + H_2O$$

$$Fe_3O_4 + 3H_2S + H_2 \rightleftharpoons 3FeS + 4H_2O$$

Regeneration of a sorbent is carried out by air on reactions:

$$Fe_2S_3 + 1.5O_2 \rightleftharpoons Fe_2O_3 + 3\,S$$

$$2FeS + 1.5O_2 \rightleftharpoons Fe_2O_3 + 2\,S$$

Depending on amount of the air given on regeneration it is possible to receive both elemental sulfur, and sulfur oxides. The method is characterized by low cost, possibility of regeneration of a chemisorbent, but its essential shortcoming is low extent of cleaning of hydrogen sulfide (to 10 mg/m3) and impossibility of use of the formed sulfur.

When cleaning by means of zinc oxides reactions not only with hydrogen sulfide, but also with other sulphurous connections proceed:

$$H_2S + ZnO \rightleftharpoons ZnS + H_2O$$

$$CS_2 + 2ZnO \rightleftharpoons 2ZnS + CO_2$$

$$COS + ZnO \rightleftharpoons ZnS + CO_2$$

$$RSH + ZnO \rightleftharpoons ZnS + ROH$$

Temperature of process 350-400 0C, and the seroyemkost of a sorbent reaches 30%. A residual sulfur content in gas to 1mg/m^3. Process rather universal,

is widely used in the industry, however thus the chemisorbent is not subject to regeneration. When cleaning by means of copper oxides process proceeds with a high speed, but the chemisorbent is also not subject to regeneration.

The hemosorbtsionno-catalytic system was widely adopted. At the first stage carry out catalytic hydrogenation of seroorganichesky connections to hydrocarbons and hydrogen sulfide, and further - hydrogen sulfide chemisorption by absorbers (zinc oxides, iron or copper). In Russia the low-temperature chemisorbent of GIAP-10-2 on the basis of zinc oxide with the activating copper oxide additive is developed.

Close to it is *an iron-soda method.* It is based on use as absorption solution of a suspension of hydroxide of two - and trivalent iron

H2S+Na2CO3 NaHS + $_{NaHCO3}$

3NaHS+2Fe Fe2S3+3NaOH+3H2O (OH)3

NaHS+2Fe (OH) 3 2FeS + S + 3NaOH+3H20

Regeneration of absorption solution is carried out a transmission of air through it. Thus about 70% of hydrogen sulfide are transferred to element sulfur, and 30% - are oxidized to sodium thiosulphate.

In summary it should be noted that the main advantage of all processes of purification of natural gas of hydrogen sulfide with firm sorbents is simplicity of hardware registration and ease of carrying out technology process actually of gas treatment, especially, in case of use of the cheap not regenerated sorbents on the basis of iron oxide.

Common fault of such processes is the low line speed of gases in gas purification devices (10 times less than at absorbing processes). That is for purification of gases with firm sorbents gas-purifying devices with an area of section of 10 times bigger are required, than at absorbing cleaning.

2.1. The equipment implementing adsorption process

At the adsorptive division it is required to carry out the following main stages.

Adsorption - engagement of the mix which is subject to division with adsorbent as a result of which certain blend components are adsorbed, and remained are brought out of a layer. At the adsorptive division of liquid mixes in many cases add solvent which is badly adsorbed to them. Its basic purpose consists in the decrease in viscosity of the environment facilitating diffusion of the adsorbed components.

Desorption - engagement of the fulfilled adsorbent with the desorbing agent for the purpose of extraction of the absorbed components and achievement of necessary extent of regeneration of adsorbent. For simplification of a desorption and reduction of an expense of the desorbing agent, and also forfuller regeneration of adsorbent process of a desorption, as a rule, provodyatpr to the increased temperature.

Removal of the desorbing agent from a layer of adsorbent and preparation of adsorbent for carrying out adsorption or oxidizing regeneration. Removal of the desorbing agent from an adsorbent layer often is followed by cooling of a layer up to the adsorption process temperature.

In case of application of oxidizing regeneration of adsorbent there is a substantial increase of temperature of adsorbent and therefore before a stage of adsorption special cooling of adsorbent is required.

Separation of the desorbing agent and solvents from target products one way or another (distillation, rectification, upholding) is an auxiliary stage of process of adsorption which calculation is made by the methods stated in other heads.

In the oil-processing and petrochemical industry adsorbers of the following main types are applied:

1) with a motionless layer of adsorbent;
2) with a moving bed of adsorbent;
3) with a fluidized layer of adsorbent.

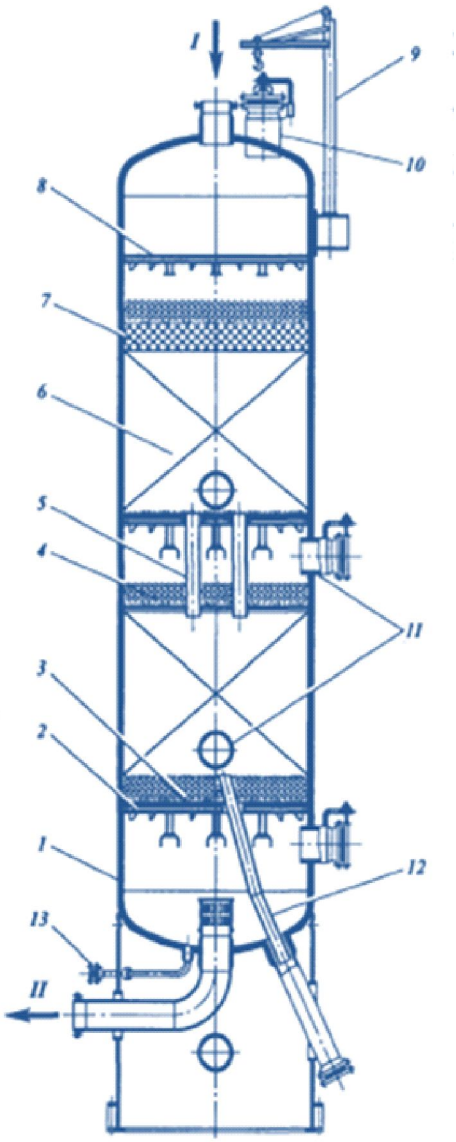
Adsorbers with a motionless layer of adsorbent represent the vertical devices filled with the granulated adsorbent. In industrial practice the general height of a layer of adsorbent is predetermined by its necessary volume and size of hydraulic resistance of a layer of adsorbent; usually it makes from 2 to 12 m.

The adsorber intended for purification of natural gas of hydrogen sulfide and mercaptans is presented on drawing. In the body of the device 1 with a diameter of 3,6 m two layers of NaX zeolite 3,6 m high are located on height. Each layer of zeolite 6 is supported by a basic grid 2 on which perforated sheet 3 and two layers of the metal gauze is established. Over a top coat of zeolite the aluminogel 7 layer for gas dewatering is placed in addition. For reduction of dynamic influence of a gas flow and its more uniform distribution over adsorbent the layer of porcelain spheres 4 300 - 600 mm high is located. When loading adsorbent use the union 10 and the crane strut 9. The adsorbent overflow from one zonyv another at its

loading and unloading is carried out on pipes 5. Unloading of adsorbent from the device is made on the pipeline 12.

Designs of adsorbers with the radial movement of a gas flow are developed for reduction of hydraulic resistance of a layer of adsorbent. In drawing options of the adsorbers intended for cleaning of gas emissions of organic substances which under the terms of a desorption can be not sectioned and sectioned are shown. The adsorber consists of the body 2 in which the ring grids 3 holding an adsorbent 4 300 - 650 mm thick layer are placed. Grids are formed of two layers of the metal gauzeof frame 18 x 2,5 mm and filtering 2 x 1 mm. For convenience of mounting and dismantle ring grids on height are separated into the identical sites connected among themselves by means of a boltless self-sealing detachable joint. Loading of adsorbent is made via the top choke 5, the fulfilled adsorbent is removed from a layer when raising a lock 8 unloading devices.

Pic.№2



Adsorber of axial type with a motionless layer of adsorbent:

1 - body; 2 - basic grid; 3 - perforated leaf and two layers of a grid; 4 - porcelain spheres; 5 - reexact pipes for loading (unloading) of adsorbent; 6 - zeolite layer; 7 - aluminogel layer; 8 - a grid, - 9 - the crane strut; 10 - the union for adsorbent loading; 11 - hatch manhole; 12 - the pipeline for adsorbent unloading. Flows: I - initial gas; II - discharge gas

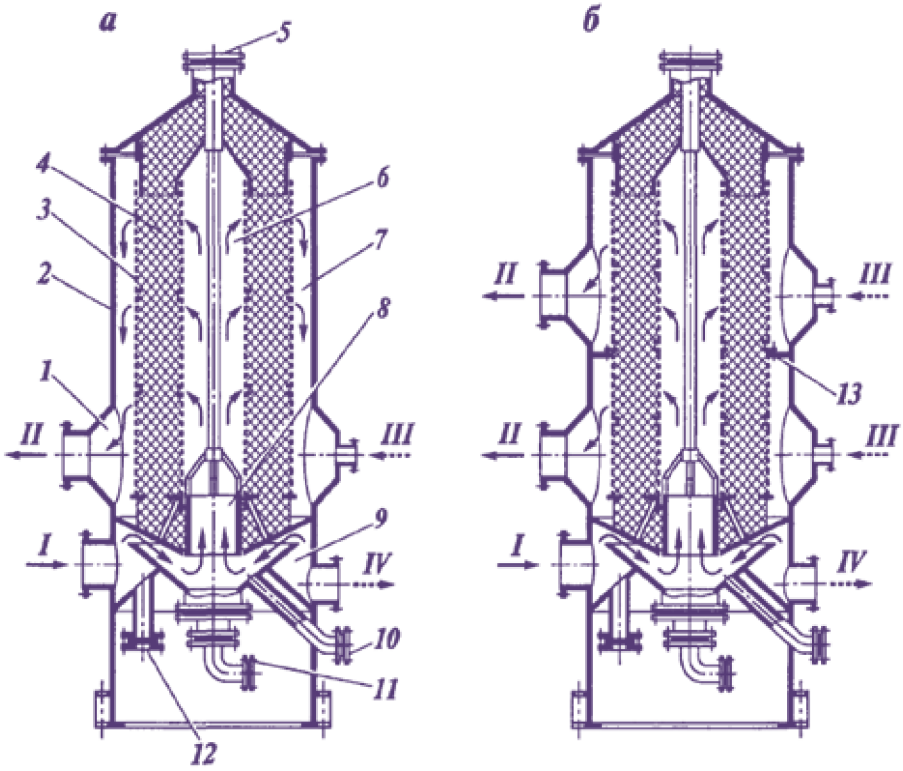
The space limited to a ring grid of smaller diameter is the central distributing canal. The space between a wall of the body and a ring grid of bigger diameter is the collecting ring channel 7.

Initial gas through the distributing collector 9 comes to the central distributing channel 6, passes through a layer of adsorbent 4 and gathers in the ring channel 7, from where through the collecting collector / is released into the atmosphere.

The desorption of organic substances from adsorbent is carried out by sharp water vapor at a temperature of 105-140 °C. Mix of stripped organic substances and waters is removed from the lower part of an adsorber via the union 10. After the termination of a stage of a desorption adsorbent drying is carried out by the warmed-up atmospheric air at first at a temperature of 60-100 °C and then cooling with an atmospheric air. Under the terms of technology

of process of purification of gases of a stage of drying and cooling can be excluded.

Pic.№3



For the purpose of protection against sudden increase of pressure at possible fire or explosion of vapor-air mixture the adsorber from the distributing collector 9 is supplied with the safety discontinuous membrane 12 working with a pressure over 0,075 MPas.

Adsorber of radial type with a motionless layer of adsorbent:

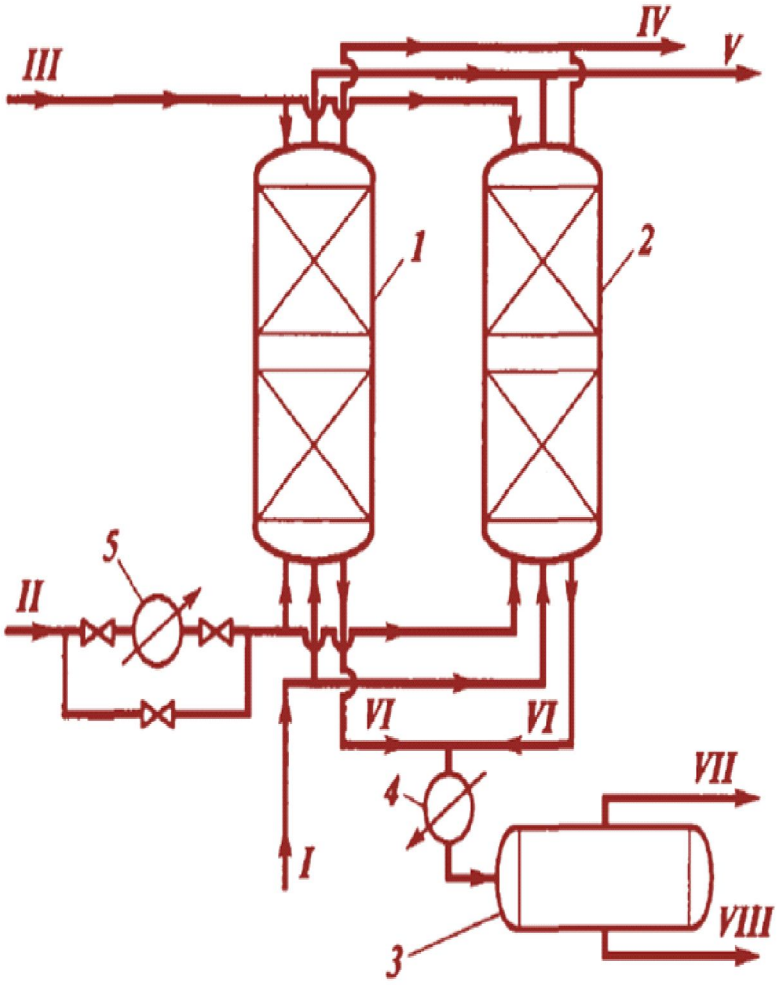
and - not sectioned; - sectioned; 1 - the collecting collector; 2-;;;;;;; 3 - ring grid; 4 - adsorbent layer; 5 - the union for adsorbent loading; 6 - the central distributing canal; 7 - the ring collecting channel; 8 - unloading device; 9 - the distributing collector; 10 - the union for adsorbent unloading; 11 - the union for condensate draining; 12 - safety discontinuous membrane; 13 - the partitioning partition. Flows: I - initial gas; II - discharge gas; III - water vapor on a desorption; IV - mix of vapors of water and an adsorbate

In adsorbers with a motionless layer of adsorbent all stages of process proceed in a certain sequence in one device and for continuous work of installation it is necessary to have some devices working on a certain cycle. The continuity of work of such installation is provided to that adsorption stage productivity precisely corresponds to the total duration of stages of a desorption, a cooling sushkiya. If duration of stages of a desorption, drying and cooling exceeds adsorption stage duration, the continuityof work of installation is reached by application of two and bigger numbers of adsorbers.

According to the scheme shown in drawing during an adsorption stage the separated gas mix comes to one of adsorbers, thus the taken components are adsorbed, and dry gas is removed from the device. At the same time in other adsorber where the adsorption stage has already come to the end, water vapor for a desorption of the taken components sent at first to the condenser refrigerator

and further to the dehydrator is entered. Then give heated air for adsorbent drying, and then a cold air for final preparation of adsorbent for the subsequent cycle of adsorption.

Switching of adsorbers is carried out automatically by means of the regulator working according to the set schedule.

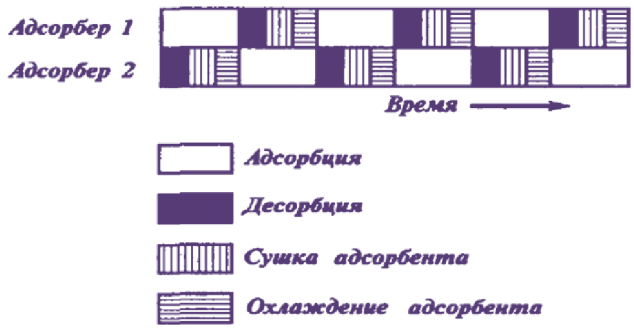


The cyclic working schedule of adsorbers is given in drawing. In case of the adsorptive division of liquid initial raw materials the schematic diagram of installation with the switching adsorbers remains same. As the desorbing agent in this case use different solvents which can be applied and to adsorbent cooling.

Adsorbers with a moving bed of adsorbent are applied to extraction of ethylene from its mix with hydrogen and methane, hydrogen from mix of gases, etc. In this case process is conducted continuously and each its stage is carried out in a certain device or part of the device, and adsorbent consistently moves between separate devices on system of pneumotransport. As adsorbent the granulated absorbent carbon is often applied.

Pic.№4.The scheme of the adsorptive installation with two adsorbers:

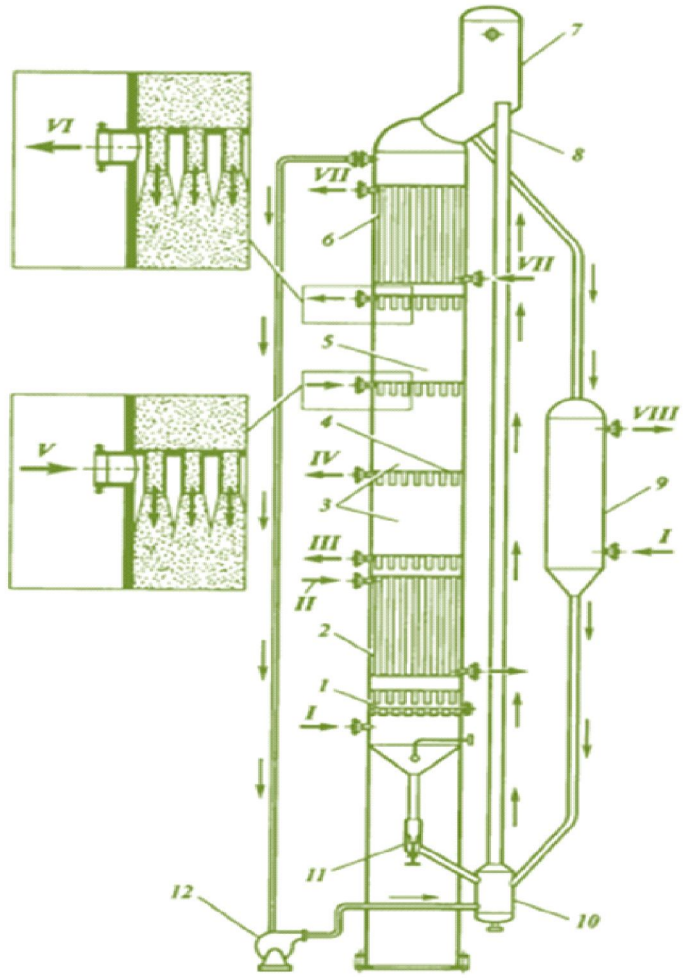
1, 2 – an adsorber; 3 – dehydrator; 4 – refrigerator; 5 – heater. Flows: I – initial gas; II – air on drying and cooling; III – water vapor on a desorption; IV – air from desorber; V – gas; VI – mix of vapors of water and an adsorbate; VII – an adsorbate; VIII – water



Pic.№5

Cyclic schedule

The scheme of an adsorber with a moving continuous bed of adsorbent for division of mix of gases is presented on drawing. The device combined consists of separate zones in which are carried out adsorption, a desorption, heating and cooling of adsorbent. Via the device a continuous layer by gravity from top to down the granulated adsorbent arriving from the bunker 7 continuously moves. It consistently passes through the corresponding zones of the device in which this or that process proceeds.

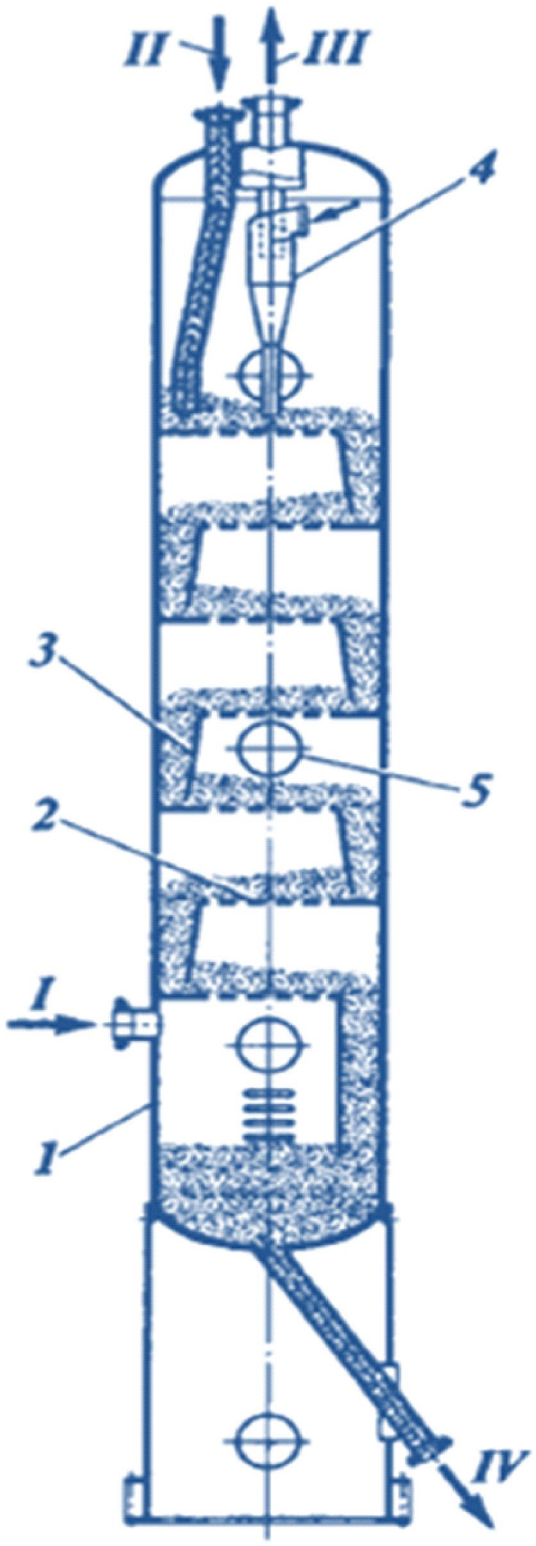


Pic.№6

The fulfilled adsorbent from a device bottom through the feeder 1 regulating amount of the adsorbent circulating in system goes to the collection of the 10th pneumoelevator where the gas blower 12 supplies the transporting gas. Further adsorbent under the influence of a gas stream rises in the upper bunker 7, from where again goes to upper part of an adsorber.

The initial gas which is subject to division, conditionally considered as consisting of mix of easy and heavy fractions, goes under a distribution plate, is evenly distributed on all section of the device and comes into contact, to a moving bed of adsorbent. Through tubes of a distribution plate gas comes to an upper adsorptive zone 5 where in a countercurrent to adsorbent there is an adsorption. From upper part of this zone light fraction is taken away. In process of gas movement up in the

adsorptive zone there is a mass exchange as a result of which the molecules of gas which are subject to extraction force out from an adsorbent surface less active molecules of light fraction, eventually, from top of this zone receive rather pure light fraction with high concentration in it low-active components of initial mix.



In a zone of input of initial gas the adsorbed phase on structure is close to structure of an adsorbate, equilibrium with initial gas, and, therefore, contains along with the taken components and components of light fraction.

Pic.№7. Adsorber with a moving bed of adsorbent for division of gases:

1 - feeder; 2 - heater; 3 - rectification zone; 4 - distribution plate; 5 - adsorptions; - the refrigerator; 7 - bunker; 8 - pneumoelevator; 9 - reaktivator; 10 - collection; 11 - the regulating latch; 12 - gas blower. Flows: I - water vapor; II - the heating agent; III - heavy fraction; IV - intermediate fraction;V - initial gas; VI - light fraction; VII - a cooling water; VIII - products of reactivation and water vapor.

In different sections of the device there are four distribution plates 4 providing uniform motion of counter flows of adsorbent and gas on all section. The same distribution adaptations are used for collecting the gas separated from adsorbent, and its conclusion from the device.

For receiving the taken components of high purity it is necessary to remove components of light fraction from an adsorbent surface. This process is also carried out in the zone 3 called a rectification zone where the mass exchange similar to process of rectification in the lower part of the rectifying column proceeds.

The components of heavy fraction desorbed in the heater 2 come to the lower part of a zone of rectification 3, and at engagement to a counter flow of adsorbent there is a mass exchange at which the components of light fraction

containing in an adsorbate are forced out and substituted with more active molecules of heavy fraction.

Thus, a gas phase, moving from below up, it is more and more enriched with components of light fraction whereas the adsorbate when moving adsorbent from top to down is more and more enriched with components of heavy fraction. From the lower distribution plate adsorbent together with the adsorbate consisting generally of components of heavy fraction comes to the heater 2 in which adsorbent heats up and heavy fraction is desorbed.

For simplification of a desorption in the lower part of the device water vapor moves. Warmly for heating of adsorbent and a desorption it is brought by the heating agent, for example the water vapor coming to interpipe space of the heater 2. Stripped heavy fraction is partially taken away from the lower distribution plate as a target product, and partially as the internal circulating flow through tubes of a distribution grid goes to a rectification zone for engagement with adsorbent. For increase of purity of an upper and lower product in a middle part of a zone of rectification intermediate fraction is taken away.

Heated adsorbent on the pneumoelevator 8 goes to the bunker 7, from where after department of the transporting gas comes to the refrigerator 6.

In the presence in initial gas of the components differing in high adsorptive capacity and therefore difficult desorbed, the last collect in the circulating adsorbent that can lead to considerable decrease in its activity. For maintenance of activity of adsorbent at the constant level the scheme of installation joins a reaktivator 9 through which the part of adsorbent circulates. In a reaktivator more severe conditions of a desorption (more high temperature, the raised consumption of water vapor, oxidizing regeneration, etc.) are created.

Use of the separate device (reaktivator) in which more severe conditions of a desorption for part of the circulating adsorbent podlerzhivatsya, in some cases it is economically more favorable, than creation of the same conditions in the heater for all flow of adsorbent. In this case it is necessary to increase considerably the sizes of the heater and an expense of the heating agent and water vapor for a desorption.

The similar method of division of gas mix has received the name of hyper sorption.

Adsorbers with a fluidized layer of adsorbent allow to carry out continuous process of adsorption also. In this case as adsorbent small granules are used (normal no more than 500 microns). Structurally the adsorber can have one or several boiling layers providing contact of phases in a countercurrent (a step and counterflow adsorber). In such adsorber on special contact devices (plates) interaction between gas and powdery adsorbent therefore adsorbent is transferred to a condition of pseudo-liquefaction is carried out. Adsorbent, moving from top to down via reexact devices, it is transferred from one contact step to another. Gas moves in the device a countercurrent from below up. For department from a gas stream of parts of adsorbent before an exit from an adsorber gas is directed to cyclones. In devices with the fluidized (boiling) layer of adsorbent it is possible to

intensify process of a mass transfer at adsorption due to reduction of the size of granules and more intensive updating of their contact surface.

The scheme of an adsorber with a fluidized layer of adsorbent: 1 - body; 2 - contact plate; 3 - reexact device; 4 - cyclone; 5 - hatch manhole Flows: I - initial gas; II - the regenerated adsorbent; III - discharge gas; IV - the fulfilled adsorbent

In drawing the scheme of the adsorptive installation intended for extraction of hydrocarbons from gases is shown. In an adsorber / there is an absorption, and in an adsorber//for the same time desorption, drying and cooling. From adsorber / gas comes to the distribution line. On the scheme the desorption cycle in an adsorber//therefore latches and and are open is shown and water vapor comes to an adsorber. The driven-away hydrocarbons together with water vapors come to the condenser 1 where the most part of water vapors is condensed; the water which is formed thus separates in a separator 2, and vapors of hydrocarbons with the remained small amount of water vapor are condensed in the condenser 3. Water separates in a separator 4; from a separator hydrocarbons go to the collection, and uncondensible couples - to a compression for their transfer in condensate.

After the termination of a desorption of a latch and would also close, would open latches, d and start the gas blower 5. Before it water vapor in a heater would move; heating up in it, gas comes to an adsorber//through latches in and. Leaving an adsorber//through a latch d, gas gets to the condenser 7 and further is sucked in by the gas blower 5. After a while, when from an adsorber//the water vapor which has remained in it after a desorption will be forced out and condensed in the condenser 7, a latch e close and gas circulation begins: via the gas blower, a heater 6, an adsorber//, the condenser 7 and again the gas blower. Absorbed by gas in an adsorber//moisture is condensed in the condenser 7. After the end of drying stop a steam supply in a heater 6 and gas goes by it; thus the cycle of cooling of an adsorber//begins. After its termination the gas blower 5 is switched off, and latches switch for transfer of an adsorber//to absorption, and an adsorber / to a desorption.

2.2. Process of a desorption at Adsorption

Process of a desorption is applied to allocation of the components absorbed at adsorption for the purpose of their direction for further processing. When in a gas stream or in the solution passing through an adsorbent layer, concentration (partial pressures) of the adsorbed components is lower equilibrium, these components will leave a surface of adsorbent and to pass into a gas (liquid) stream, i.e. to be desorbed. It will occur until the new equilibrium state is established.

On commercial adsorptive units it is necessary to make regeneration of adsorbent for the purpose of recovery of its adsorptive capacity. Therefore after the termination of a stage of adsorption the stage of a desorption of the absorbed components from adsorbent is carried out.

Adsorbent regeneration process (desorption) can be carried out the next main ways.

1. Replacement of the absorbed components from an adsorbent surface other substance possessing higher adsorbability with the subsequent its allocation from adsorbent which does not cause difficulties. So, for example, at the adsorptive division of mix of hydrocarbon gases as the desorbing agent it is possible to use water vapor. At absorption by adsorbent of water vapor the last forces out hydrocarbons and takes their place. Thus water vapor is condensed, there is an allocation of warmth of condensation that promotes a desorption as process temperature increases. For a complete recovery of activity of adsorbent upon termination of a desorption of its hydrocarbons it is necessary to exempt from the absorbed moisture in the beginning, i.e. to dry up, and then to cool up to the temperature at which adsorption process proceeds. At the adsorptive division of liquid hydrocarbon mixes as the desorbing agent the different organic liquids possessing higher adsorptive capacity in comparison with the absorbed components, for example, low-molecular aromatic hydrocarbons (benzene, toluene, xylols) or their mixes with polar solvents (alcohols, ketones) can be used. Depending on type of the applied desorbing agent these or those methods of its removal from adsorbent are used.

2. Replacement of the adsorbed components by the substance possessing smaller adsorbability (unpolar solvents). In this case process of a desorption is carried out due to violation of an equilibrium state between an adsorbate and the solution proceeding through an adsorbent layer and caused by smaller concentration of these components in solution, than corresponding to a balance condition with an adsorbate. For example, at the adsorptive division of different oil products by the desorbing agent there can be a gasoline fraction differing on temperature limits of boiling from initial mix that allows to separate further this gasoline fraction from stripped components simple distillation or rectification.

3. Evaporation of the adsorbed components when heating adsorbent or when lowering the general pressure in system or the partial pressure of the adsorbed components. Such method of a desorption can be used at division of mixes of rather volatile components.

4. Oxidizing regeneration at which the adsorbed components delete from adsorbent by their burning. This method is applied when the adsorbed substances differ in very high adsorptive capacity and removal them in the ways stated above is almost impossible. Resort to this way of regeneration of adsorbent when the adsorbed components are not target and their loss in the form of combustion products is admissible for economic and ecological reasons. Removal of asphaltic substances from an adsorbent surface can be an example.

2.3. Adsorption with a motionless layer of adsorbent

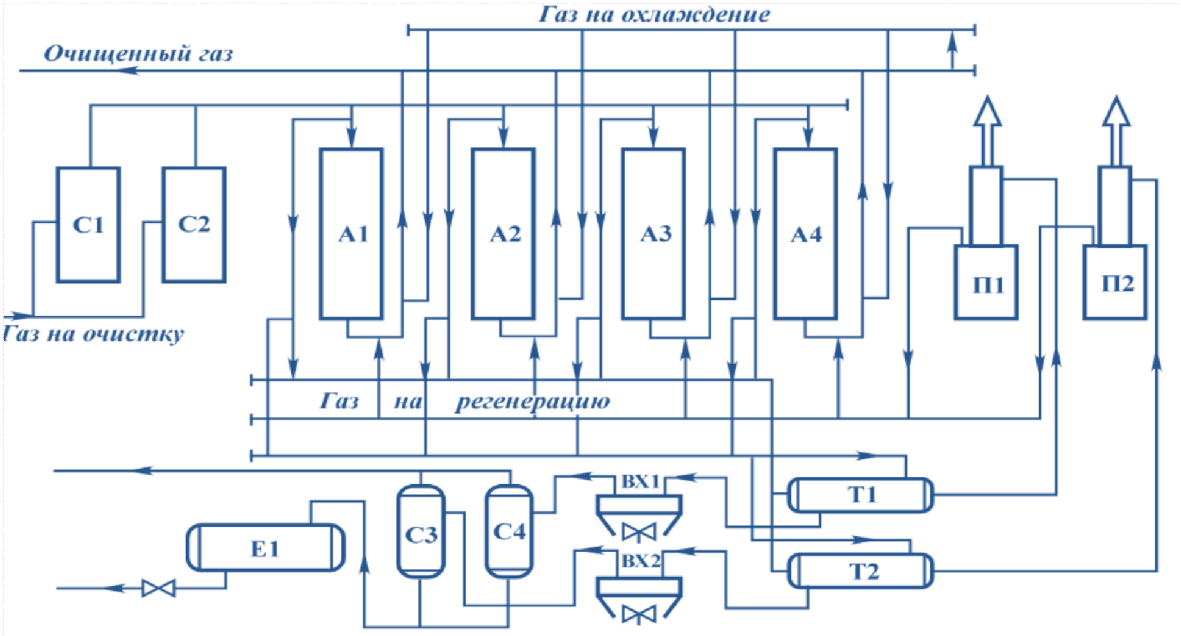
Most widely now the periodic method of adsorption with a motionless layer of adsorbent is widespread in the industry. Adsorption is carried out for four operations (cycles): absorption (adsorption) by gas coal from mix, its driving off from coal (desorption), drying of coal and cooling. After cooling the adsorber again joins on absorption. Thus, for continuous absorption it is necessary to have some adsorbers which in turn join on absorption. Usually installations consist of two, three or four adsorbers.

The scheme of the four-adsorptive installation is given in drawing. The natural gas containing sulphurous connections moves on the pipeline through two entrance separators of C1 and C2 in a distribution collector of adsorbers. Separators are intended for department from a flow of raw gas of the dropping liquid which is carried away with gas from the previous departments of desulphurization and gas dewatering. From a collector gas comes to two in parallel working an adsorber, being at a cleaning stage from top to down. For cooling and regeneration the same gas flow which is selected from a collector of purified gas is used. Cooling gas after an adsorber with a temperature of 40-300 °C is supplied in pipe space of T1, T2 heat exchangers like "gas - gas" and then with a temperature of 1 70 °C - in the furnace of heating of P1, P2. T1, T2 heat exchangers are intended for partial recuperation of heat of gases of regeneration, and also for maintenance of continuous temperature of gas in front of furnaces of heating and air BX1, BX2 refrigerators. From the furnace heated gas comes from below up to the adsorber which is subject to regeneration then with a temperature of 40-320 °C goes to pipe space of T1, T2 heat exchangers where 170 °C are cooled up to the temperature ~, from where moves in BX1, BX2 aero refrigerators, separators of C1, C2 of gases of regeneration and further in a collector of gases of regeneration.

On a method of utilization of gases of regeneration commercial units of desulphurization can be separated into three types:

- installations with an open cycle when gas of regeneration is used as fuel gas or, having taken place system of cleaning and an osushka, moves in the gas pipeline of purified gas;
- installations with the closed cycle when gas of regeneration is exposed to cleaning and then returns to a flow of the cleared gas;
- installations with the closed contour of gases of regeneration when regeneration gas after cleaning and an osushka is used for regeneration zeolite again.

The adsorptive installation with an open cycle for purification of natural gas of mercaptans is built by the El Paso Natural Gas company. Productivity of installation is 5,7 million m^3 gases per day. The content of mercaptans in gas before cleaning of 137 mg/m^3 and 1,37 mg/m^3 respectively. Gas arrives on cleaning with pressure of 5,27 MPas, temperature of adsorption of 40 °C, regenerations of 320 °C, duration of stages: adsorptions of 12 h, regenerations of 8 h, coolings of 4 h.



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Two horizontal devices with a diameter of 1,83 m and 14 m long are used. Gas of regeneration is used as process fuel. Installation of this kind works on ON "Kuibyshev-burmash". It is intended for purification of natural gas of sulphurous connections before use of natural gas for preparation of the controlled atmospheres. Productivity of installation is 3000 m3/h, concentration of hydrogen sulfide in the cleared gas of 5-7 mg/m^3, mercaptans of 20-36 mg/m^3, the content of sulphurous connections in purified gas no more than 1 mg/m^3. Gas arrives on cleaning with pressure of 3-6 atm, temperature of adsorption of 40 °C, regenerations of 320 °C. Duration of stages: adsorptions of 24 h, regenerations of 16 h, coolings of 8 h. Two vertical adsorbers with a diameter of 1,4 m and 4 m high are used. The third adsorber - reserve. Regeneration gas in number of 200 m3/h by means of the ejector it is mixed with a natural gas stream, arriving on factory combined heat and power plant. The scheme of the adsorptive installation in which regeneration gas, having passed installation of amine treatment and a glycolic osushka is provided in work, moves in the main gas pipeline.

In commercial adsorptive units the system of liquid purification of gases of regeneration is calculated with the closed cycle taking into account peak concentration of sulphurous connections (see the previous chapter). For smoothing of peaks usually construct some technology strings of the adsorptive gas treatment which work in the parallel mode with shift in time.

With the closed cycle it is possible to give the installation developed by the Engineers and Fabricator company as an example of installation. Productivity of installation is 2,8 million m^3 gases per day. The scheme has included the additional scrubber irrigated by absorption oil. Installation cost, including 53 t of zeolites, makes 1 million a dale. The rated cost of amine installation of similar power is estimated at the level of 1, 5 million a dale. without the cost of the draining installation which accompanies wet cleaning. Technical and economic

calculations are given in relation to the gas containing 60% $_{of\ CO2}$ and 0,5-0,7 g/m^3 hydrogen sulfides and mercaptans.

The half-open cycle of regeneration is applied to the adsorptive installations of small power. This option is characterized by that during regeneration burn part of gas with peak concentration of sulphurous connections on a torch, and other gas of regeneration return in a flow of the cleared gas.

Losses of gas in such systems can be reduced to the level of 5% from the volume of the recycled gas. Also following sequence of operations at a regeneration stage is used. Regeneration gas constantly circulates through an adsorber until the layer of adsorbent does not heat up to required temperature. Then the final purge of adsorbent by gas for removal of bulk of sulfur and cooling is carried out.

In order that in the closed contour water vapors did not collect, the additional block of an osushka is provided by zeolites. Gas losses in this case make less than 5% of refining capacity. On such technology on Volzhsk automobile plant the installation consisting of three adsorbers is operated: one is on adsorption, the second - on regeneration and cooling, the third - reserve. Circulation of gas of regeneration is carried out by ejection by nitrogen.

Key technology parameters of work of installation

Productivity, m3/h……2000
Gas pressure on an entrance in
installation, mm of mercury…….1700-1800
Temperature of gas, °C ……..…20-25
Amount of the zeolite loaded into one adsorber, kg…….……1000
Consumption of technical nitrogen on regeneration, m3/h……..25-30
Frequency rate of circulation of nitrogen…….5-6
Stage duration, h:
Adsorptions……...24
Regenerations……...12
Coolings……12

Range of operating conditions in which the adsorptive installations of desulphurization can be operated

Productivity,
one thousand m3/day……...25-25000
Excessive pressure, atm……5-84
Temperature, °C……..……20-50
Content of sulfide
hydrogen, mg/m^3……20-6650
Content of mercaptans,
mg/m^3……15-1000
Content of carbon dioxide, % pier……1-50
CO2/H2S relation in gas……to 1000

Technology features of the adsorptive purification units of natural gas from sulphurous connections in addition to actually adsorptive system are shown also in a way of purification of gases of regeneration of zeolites which gets out taking into account structure of sulphurous connections.

In all cases after purification of gases of regeneration of sulphurous connections its osushka is required. Most often washing with glycols is for this purpose applied.

Technical and economic indicators of process of purification of gases of regeneration of zeolites in many respects depend on conditions of production where the adsorptive installation is operated. For example, on petrochemical and nitrogen fertilizer plants from gases of regeneration of seroorganichesky connections it is reasonable to apply a way of their hydrogenation with the subsequent removal of the formed hydrogen sulfide to extraction in the liquid hemo-sorption way. Process of hydrogenation is carried out on the alyumokobalt-molybdenum catalyst at t = 350+ +400 oC and volume speed of gas of 800-1000 h^{-1}.

The double - threefold excess of hydrogen in comparison with stoichiometrical quantity is necessary for increase of speed of reaction of hydrogenation. After cleaning gases of regeneration go for conversion for receiving hydrogen, i.e. desulphurization installation organically fits into the general production cycle. The hydrogen consumption in such process is determined by reactions of hydrogenation of seroorganichesky connections depending on their concentration and structure.

Ways of cleaning of Tazy of regeneration of zeolites

The extracted impurity	Way of cleaning, sorbents, catalysts
H_2S, CO_2	Absorption by water solutions of chemisorbents: alkanolamines, carbonates and phosphates of alkaline metals, etc
H_2S, CO_2withimpurity COS and RSH	Absorption by the mixed absorbers including alkanolamine, physical solvent and water (for example, process of "Sulfinol")
RSN with H2S, CO2, COS impurity	Absorption by physical solvent (for example, process of "Seleksol") with the subsequent rectification of acid gases
	Absorption of H2S, CO2 by water solution of amine with the subsequent extraction of COS and mercaptans water solution of alkali (it is possible with organic additives)
	Hydrogenation of COS and RSH on the alyumokobaltmolibde-new catalyst with the subsequent extraction of H2S and S02 water solution of amine
	Hydrolysis of COS and thermal decomposition of RSH on silica-alumina catalysts with the subsequent extraction of H2S and SO2 water solution of amine

The method of hydrogenation is unacceptable for gas-processing plants due to the need of building of installation of receiving hydrogen and its big expense.

For purification of gases of regeneration of zeolites of mercaptans in relation to conditions of gas-processing plants two methods are offered. The first is based on thermocatalytic decomposition of mercaptans to hydrogen sulfide on high-silicic zeolitic catalysts. In the second method reaction of mercaptans with elemental sulfur with formation of pentasulphides and hydrogen sulfide is used. Both ways are in a stage of pilot check on ON "Orenburggazzavod".

Process of direct oxidation is of interest to purification of gases of regeneration of hydrogen sulfide. Air in the quantity necessary for oxidation of hydrogen sulfide to elemental sulfur is mixed with gases of regeneration:

$2H2S + {}_{O2} = 2H2O + 2S.$

Then vapor-air mixture passes through a catalyst layer at t = 250 oC. After cooling of gases the formed sulfur separates in a seroulovitel.

2.4. The description of laboratory installation of the adsorptive gas treatment from acid impurity zeolites

The adsorptive methods of purification of gases are based on the selection extraction of acid components by firm absorbers - adsorbents. In that case when the taken component is kept by adsorbent (absorbent carbon, zeolites) only physical forces, *physical adsorption* takes place. If the taken component enters with adsorbent (iron oxides, zinc, molybdenum) in chemical interaction speak about *chemical adsorption.*

Effective adsorbents of carbon dioxide - *zeolites*. Molecules of carbon dioxide are rather small. Their diameter makes about 0,31 nanometers (3,1 A) that allows them to get into internal structure of the majority of zeolites. The desorption of the absorbed components is carried out pressure reduction and temperature increase.

Molecular a sieve (zeolites) are synthetic crystal aluminosilicates in which framework silicon and aluminum are in a tetrahedral configuration, and the containing alkaline metals. The structure of zeolites is provided by system of regular channels and the reported planes with a size of time from 0,3 to 1,0 nanometers depending on zeolite type. During process of adsorption of impurity, present at gas, should prodiffundirovat through a time and surfaces of the internal planes. In the industry the zeolites created in the form of tablets or balls about 3 mm in size are applied.

In comparison with other adsorbents molecular a sieve have big absorption ability, are less subject to pollution and coking up, extract impurity and, thanks to availability of the adjustable size of a time better, possess unique selectivity of adsorption depending on the sizes of molecules. Their use allows to reduce the specific volume of adsorbent, to work at lower pressure differential at an adsorbent layer, to exclude losses of gas because of adsorption of a number of its components, to ensure longer and reliable functioning of installation.

Most often for adsorption use SAA zeolite. Process goes under pressure of 1,7-5 MPas. Together with carbon dioxide zeolites absorb also water vapors. Therefore along with purification of gases of carbon dioxide there is their osushka.

Work purpose

Option 1

Research of process of adsorption of acid impurity of gas (in particular $_{CO2}$) zeolites under the conditions set by the teacher (temperature, amount of adsorbent, concentration $_{of\ CO2}$ in initial gas, time of carrying out experience), an assessment of efficiency of effect of adsorbent under the set conditions.

Option 2

Studying of influence of the nature of adsorbent (zeolites of different brands - SAKHA, NaA, CaA, NaX, absorbent carbon, etc.) and process parameters on extent of extraction $_{of\ CO2}$. Installation allows to estimate influence on process of extraction $_{of\ CO2}$ of gas of the following factors: type of the used adsorbent; amount

of adsorbent; contact time adsorbent/gas; the maintenance $_{of\ CO2}$ in initial gas; adsorption temperature.

Installation of the adsorptive cleaning

The schematic diagram of installation is given in figure 2. The main nodes of installation are: an adsorber 1 with a water jacket for maintenance of necessary temperature by means of the thermostat 3; the pump 2 for supply of absorbent and a node of preparation of gas mix of the set structure - cylinders with compressed gases 6, reducers 12, rheometers 4.

Model gas prepares by the dosed supply of impurity (CO2) in a gas flow - the nitrogen carrier.

Order of carrying out experiment.

Open a valve on a cylinder with nitrogen and by means of a reducer and the rheometer establish a nitrogen consumption. Then give $_{CO2\ to\ a\ flow\ of\ nitrogen}$. Previously rheometers 4 for supply of nitrogen and $_{CO2}$ calibrate by air (nitrogen), selecting the corresponding capillaries 11. Feed speed of gases is controlled visually by means of the bubbler with water 10. At the same time turn on the thermostat 3 and install the heating regulator on necessary temperature.

Turn on the chromatograph (according to the instruction on operation of the chromatograph) and analyze gas, on the maintenance $_{of\ CO2}$ before receipt in an adsorber, if necessary adjusting amount of the given carbon dioxide by means of a gas reducer 12 and the rheometer 4 according to the teacher's task.

After the set gas rate and temperature in an adsorber is established, select on the analysis test of gas on an entrance to an adsorber and at the exit. In 20-30 minutes of stable work of installation again select on the analysis test of gas on an entrance to an adsorber and at the exit; for reliability of results repeat the analysis with selection of new tests not less than 3 times.

The analysis of the maintenance $_{of\ CO2}$ in gas

The maintenance $_{of\ CO2}$ in gas before adsorption is determined on the Kristallyuks-4000 chromatograph with the detector by heat conductivity under following conditions: column of metal 3000 mm;

firm phase - absorbent carbon;

temperature:

- in a column - 160° C;
- in the evaporator - 165° C;

carrier gas - hydrogen;

speed of carrier gas - 50ml/mines

The results of the analysis of composition of gas received at its chromatographing bring in tab. 4 and 5.

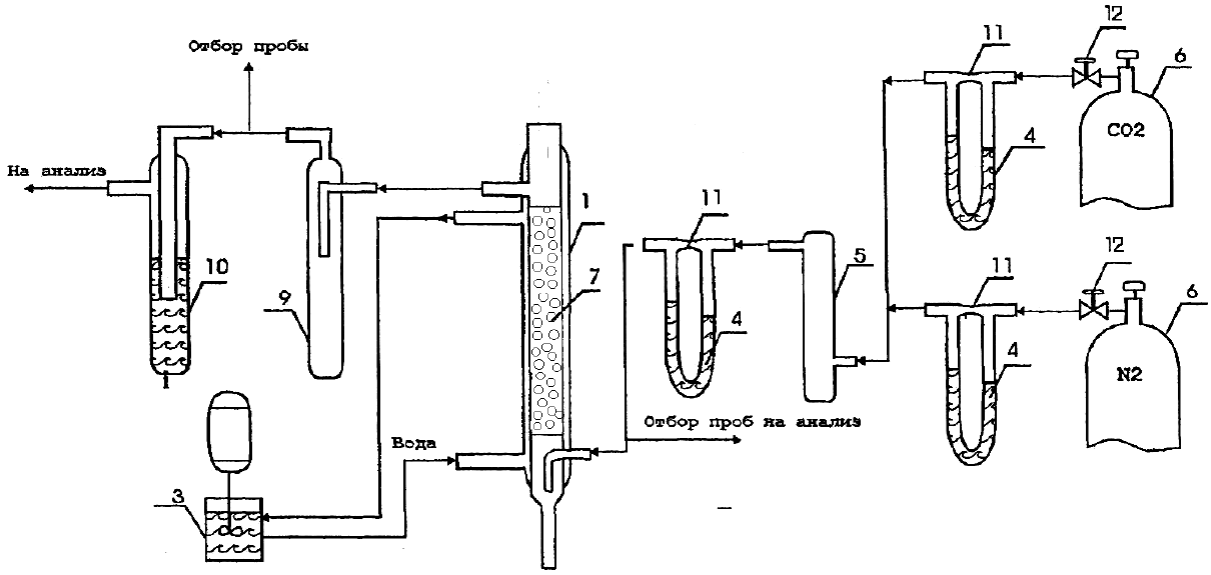


Fig. 2. Schematic diagram of laboratory adsorptive installation

1 adsorber; 2 pump; 3 thermostats, 4 rheometers; 5 mixer; 6 cylinder; 7 nozzle; the 8-graduated receiver; 9 chipper; 10 bubbler; 11 capillaries; 12-gas reducer.

Таблица 4

Состав газа до очистки

Компонент	**Площадь, S, мВ/мин**	**Поправочный коэф., К**	**S_i, S мВ х К**	**% об. $S_i/\sum S_i$**
Азот		2,04		
CO_2		1,77		
			$\sum S_i$	100

Таблица 5

Состав газа после очистки

Компонент	**Площадь, S, мВ/мин**	**Поправочный коэф., К**	**S_i, S мВ х К**	**% об. $S_i/\sum S_i$**
Азот		2,04		
CO_2		1,77		
			$\sum S_i$	100

Example of processing of experimental data

In the form of the table basic data - experimental conditions and results of supervision are registered

- date _____
- adsorbent SAA brand zeolite
- the initial maintenance $_{of\ CO2}$ in gas, % about. 2,0; 1,9; 2,1; cf. 2,0
- adsorption temperature, ° C 40
- initial pressure of nitrogen and $_{CO2}$ in a cylinder, kg/cm2 50
- feed speed of nitrogen, l/hour 8,0
- feed speed $_{of\ CO2}$, l/hour; 0,5
- amount of adsorbent,
- the final maintenance $_{of\ CO2}$ in gas, % about 1,1; 1,2; 1,0; cf. 1,0

Extent of extraction $_{of\ CO2}$ in % is calculated, considering a ratio of the maintenance $_{of\ CO2}$ in gas after adsorption to the maintenance $_{of\ CO2}$ before adsorption. In this case extent of extraction $_{of\ CO2}$ makes:

100 - 1,0/2,0x100 = 50%

If the student performs laboratory work on the II option, i.e. on the instructions of the teacher conducts research of influence of parameters on efficiency of extraction $_{of\ CO2}$ when using a certain adsorbent, it builds the schedule of dependence of extent of extraction $_{of\ CO2}$ on change of the studied parameter (temperature of adsorption, the maintenance $_{of\ CO2}$ in initial gas, etc.) and defines optimum value of this parameter in the studied interval of its values.

When studying efficiency of effect of different adsorbents the student compares extent of extraction $_{of\ CO2}$ at their use in identical conditions and defines the most effective adsorbent at the parameters set by the teacher.

3. Rated part

3.1. Calculation of an adsorber and the adsorptive purification unit of gases from acid components

The main determined sizes: diameter of the device and height of the word of a layer of a sorbent at the set process time.

1) admissible dummy speed of gas (speed in free section)

$\omega_0 = (0{,}016 \cdot r \cdot \rho_{нас} \cdot d_e \cdot g / \rho_г)^{0,5}$

d_e - the equivalent diameter of granules, m,

$\rho_г$ - the gas density, kg/m^3,

$\omega_0 \leq 0{,}3$ m/s.

Porous structure of adsorbents

The porous structure has considerable impact on the adsorptive properties of a sorbent.

The surface of a sorbent includes:

- the exterior surface depending on amount of a macrotime is also made by 0,5 ÷ 2,0 m2/h, i.e. 2,0 ÷ 0,5% of the general surface;

- the inner surface which is formed at the expense of walls of micropores. It can be equal to 500 ÷ 1000 m2/h.

Surface of a porous body:

$S = N_A \cdot a_m \cdot S_m$, where

N_A - Avagadro's number,

a_m - the adsorption size corresponding to a surface covering a continuous monolayer of the adsorbed molecules

S_m - the site occupied by one adsorbed molecule

$S_m = 1{,}53 \cdot V^{2/3}$, V - the molar volume of the adsorbed substance.

$S_{m\,N2} = 1{,}62$ m^2.

Total porosity of a solid body can be determined by its density.

Distinguish true (ρист), density of porous bodies seeming (ρкаж) and bulk (ρнас).

The true - the mass of unit of volume of the plotnoupakovanny body (which is not containing a time).

The seeming - the mass of unit of volume of a porous body including volumes of a time, but without the volume of emptiness between grains.

The bulk - the mass of unit of volume of a porous body including the volume of dense substance, volume of a time and volume of emptiness between grains.

Total volume of a time:

$V_\sum = 1/\rho_{каж} = - 1/\rho_{ист,}$ g sm^3.

Active coal $\rho_{ист,} = 1750 \div 2100$ $\rho_{каж} = 500 \div 1000$ $\rho_{нас} = 200 \div 600$

Softly granular selikogel $\rho_{ист} = 2100 \div 2300$ $\rho_{каж} = 1300 \div 1400$ $\rho_{нас} = 800 \div 850$

Largely granular selikogel $\rho_{ист} = 2100 \div 2300$ $\rho_{каж} = 750 \div 850$ $\rho_{нас} = 500 \div 600$

Zeolites $\rho_{ист} = 2100 \div 2300$ $\rho_{каж} = 1200 \div 1400$ $\rho_{нас} = 600 \div 800$

Calculation of the adsorptive installations

Consists in determination of the constructive sizes (diameter, height), the volume of adsorbent, time of protective action of hydraulic resistance and some other sizes.

1) $_{Yes} = \sqrt{\frac{4V_{\Gamma}}{\pi\omega_2}}$

Where $_{VG}$ - a volume consumption of threshold mix of m3 s,

ω_2 - the speed carried to the free section of the device, m s.

For devices with a motionless layer $\omega_2 = 0{,}25 \div 0{,}3$ m s.

2) Adsorbent volume for one-time loading in the device

$$_{Vad} = \frac{(V_{\Gamma} \cdot n_y)}{\beta_y}$$

$_{nu}$ - number of units of transfer;

$ß_y$ - volume coefficient of a masooperenos, kg $m^3 \cdot$ page.

$$n_y = \int_{y_к}^{y_н} \frac{d_y}{y - y^x} \quad \text{or} \quad n_x = \int_{x_h}^{x_k} \frac{d_x}{x^x - x} = f \cdot M_1 \cdot M_2$$

$_{un}$, $_{uk}$ - initial and final absorbate concentration in steam-gas mix,

$_{hn}$, $_{hk}$ - initial and final concentration of an adsorbate in a firm phase, kg m^3,

x, at - the current concentration of an adsorbate in firm and an adsorbtiva in a steam-gas phase, kg m^3,

x^x, at^x - equilibrium concentration of an adsorbate, kg m^3.

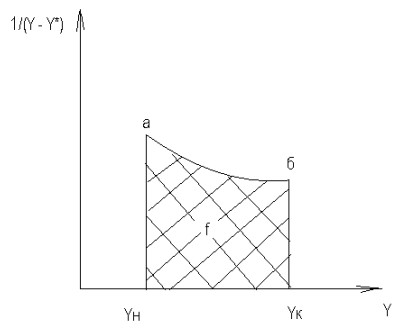
The equation can be solved by method of graphic integration. Having set by a number of at values we build the schedule in coordinates $1/(at - at^*)$ — at, and then, having measured the area of a curvilinear trapezoid we find the size of required integral taking into account scales: $_{M1} = l1/h1$ and $_{Sq.m} = l2/h2$,

$_{l1}$ - value of ordinate $1/(at - at^*)$,

$_{h1}$ - value of the same ordinate in mm,

$_{l2}$ - value of an abscissa on graphics at,

$_{h2}$ - value of the same abscissa in mm.



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For creation of the schedule used for receiving number of units of transfer it is necessary to define value at^{x} (xx). For this purpose it is required to construct isotherms of adsorption (line 2) and the working line of process (line 1). An adsorption isotherm (the curve ravnovesiya0 at t = const serves as the main characteristic of process $_{a0}$ = to f (p),

$_{a0}$ - static activity,

p - partial pressure.

Between concentration of the adsorbed substance in a gas phase and it there is Klapeyron's equation:

$$\overline{C} = \frac{P}{RT} \quad \text{kg} \quad \text{m}^3.$$

The isotherm of adsorption is built on the basis of experimental (or help) data. For creation of the working line it is necessary to know coordinates of at least two points answering to operating conditions of process.

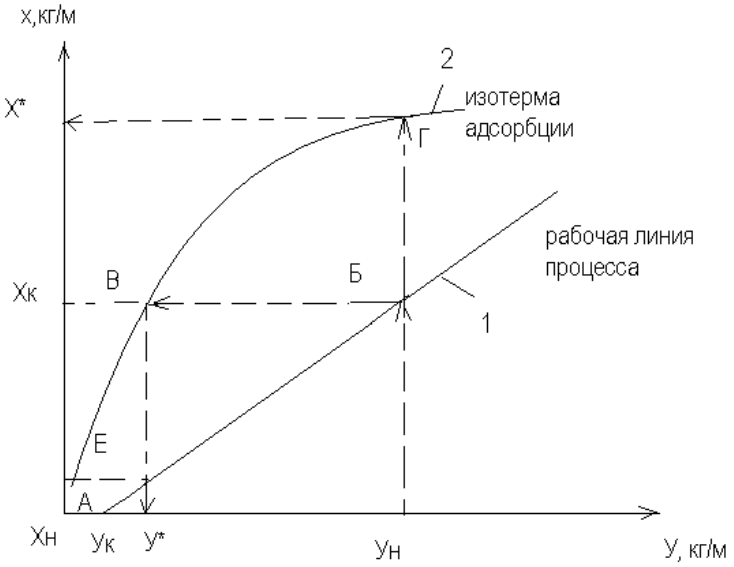
For example, if are set $_{un}$, $_{uk}$ and $_{hn}$ (initial concentration of the taken component in a firm phase), $_{hk}$ we define final concentration of adsorbent in a firm phase from the equation:

$$V_Г(y_н - y_к) = V_{ад}'(x_к - x_н) \rightarrow x_к = \frac{V_Г}{V_{ад}} \cdot (y_н - y_к) + x_н$$

$V_{ад}'$ - the adsorbent volume saturated adsorbtivy in unit of time (size of the working layer).

$$V_{ад}' = \frac{V_Г(y_н - y_к)}{x^* - x_н} \quad \text{m3} \quad \text{s},$$

Value x * (equilibrium concentration of an adsorbate in a firm phase), corresponding to a preset value "at", determine by an adsorption isotherm. Knowing coordinates (·) And ($_{hn}$; $_{uk}$) and (·) B ($_{hk}$; $_{un}$) we apply them on the schedule and we connect a straight line.



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For definition x^*, at* we are set by at values in an interval $_{un}$ - $_{uk}$. If from initial (·) $_{un}$ to continue a perpendicular before crossing with the equilibrium line 2 to (·) and to design it on an axis x, we will receive equilibrium connection of an adsorbate in a firm phase x^* at a preset value $_{un}$. If the isotherm of adsorption is unknown, it can be constructed on an isotherm of adsorption of standard substance. Value of sizes of adsorption is recalculated on a formula:

$$x_2^* = x_1^* \cdot \frac{V_1}{V_2} = x_1^* \cdot \frac{1}{\beta},$$

x_1^* - ordinate of an isotherm of standard substance (usually benzene), kg/kg,

x_2^* - ordinate of the defined isotherm, kg/kg,

$_{V1}$, $_{V2}$ - molar volumes of the standard and studied substance in a liquid state,

$$V = \frac{M}{\rho_{ж}},$$

M - the molar mass of substance, kg/mol,

β - affectivity coefficient,

$$\beta = \frac{V_2}{V_1}, \quad \beta_{бензол} = 1,$$

$\rho_{ж}$ - substance density in a liquid state, kg/m^3.

Example - to calculate an adsorber for catching of vapors of diethyl ether from air: $_{VG}$ = 2000m3 ch = 0,555m3 ch, $_{tv}$ = 20 °C, P = 760mm rt St, $_{un}$ = 0,006kg m^3, $_{uk}$ = 3 · 10$^-$ 5kg/m^3.

As adsorbent we choose active coal of the ARE brand - And, $_{de}$ = 1,3 · 10$^-$ 3m.

We accept ω_2 = 0,28m/with $Д_a = \sqrt{\frac{2000}{3600 \cdot 0{,}785 \cdot 0{,}28}} = 1{,}6м$, then

$$S_a = \frac{\pi Д^2}{4} = \frac{(3{,}14 \cdot 1{,}6^2)}{4} = 2{,}01м^2.$$

For creation of an isotherm of adsorption we use the monogram for determination of saturated vapor pressure of some substances according to which we determine the partial pressure of substances by a formula:

$$\lg P_2 = \lg P_{S,2} - \beta \frac{T_1}{T_2} \cdot \lg \frac{P_{S,1}}{P_1} \quad (1)$$

where $_{P1,P2}$ - the partial pressure of the standard and studied substance, mm of mercury (Pa),

$_{PS,1}$ - the saturated vapor pressure of standard substance at an absolute temperature (mm of mercury),

$_{PS,2}$ - the saturated vapor pressure of the studied substance.

At calculation of points of an isotherm of the studied substance of coordinate x_1^* also P_1 undertake on a curve of standard substance, PS,1, PS, 2 value - from tables of saturated vapor pressure. P2 - is calculated on a formula (1). Having expressed partial pressure through the corresponding concentration, we will receive:

$$\lg y_2^* = \lg y_{H2} - \beta \frac{T_1}{T_2} \cdot \lg \frac{y_{H1}}{y_{H2}} \quad (2)$$

Affectivity coefficient for diethyl ether (table 36, Kuznetsov) $\beta = 1{,}09$.
1) according to table 25 (equilibrium data on adsorption of vapors of benzene and their mix with air on active coals $y_1^* = 0{,}000854 кг/м^3$ $x_1^* = 109{,}0 кг/м^3$,
2) according to the chart (p. 115) we determine coordinates of points of an isotherm of adsorption of diethyl ether, PS,1 - for benzene - 75 mm of mercury (9997,5 Pas), PS,2 - for diethyl ether - 442 mm of mercury (58918,6 Pas).
3) Volume coefficient of a mass transfer:

$$K_y = \frac{1}{\left[\left(\frac{1}{\beta_y}\right) + \left(\frac{m}{\beta_x}\right)\right]}$$

β_y, β_x - volume coefficient of a mass transfer in a gas and firm phase respectively, with^{-1},
m - distribution coefficient (average $tg\,\alpha$ of an inclination of the line of balance).

$$m = \frac{y_н}{x_к^*}$$

As $\frac{m}{\beta_x}$ - it is usually very small, size it is neglected.

On the basis of it $K_y \approx \beta_y$ also depends on a hydrodynamic situation in the device, physical properties of a flow.
For the oriented Ku's calculations use the criteria equations:

$Nu' = 0.395 \cdot \mathrm{Re}^{0.64} \cdot \mathrm{Pr}'^{0.33}$ at Re> 30

$Nu' = 0.725 \cdot \mathrm{Re}^{0.47} \cdot \mathrm{Pr}'^{0.33}$ at Re = 2 - 30

$Nu' = 0.515 \cdot \mathrm{Re}^{0.85} \cdot \mathrm{Pr}'^{0.33}$ at Re <2

$$Nu = \frac{\beta \cdot y \cdot d_э^{\,2}}{Д}$$

where - diffusion criterion of Nusselt.
De - the equivalent diameter of grains of adsorbent, m

$$\mathrm{Re} = \frac{\omega_2 \cdot d_э \cdot \rho_Г}{\mu_Г \cdot \varepsilon_н},$$

ω_2 - gas flow rate, m/s

Ism	Sheet	Document №	Sign.	Date		page
Executed		Kholov R.V.				
Head		Tsukanov M.N.				

$\varepsilon_н$ - porosity of a motionless layer of adsorbent,

$\rho_Г$ - density, kg/m^3

μ_2- dynamic viscosity, Pa · with

$\mathrm{Pr}' = \frac{\mu_Г}{(Д \cdot \rho_Г)}$ - diffusion criterion of Prandtl.

4) Height of a motionless layer of adsorbent in the device

$H_н = n_y \cdot h$,

h - transfer unit height,

$h = \frac{G_Г}{S_{сл} \cdot \beta_y}$

where $_{Gg}$ –массовый gas rate, kg s

Ssl-section of a layer, m^2

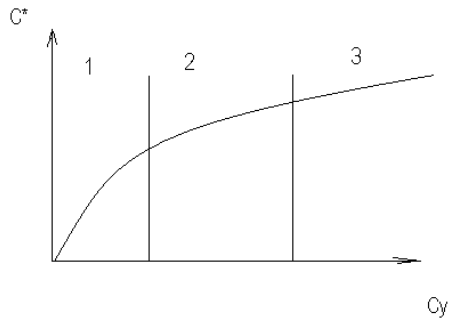
$S_{сл} = \frac{\pi Д_a^{\,2}}{4}$

5) Duration of process of adsorption is determined by a solution of the system consisting of three equations:

• the equations of balance of the absorbed substance;

• adsorption kinetics equations;

• isotherm equation adsorption.



1: $\frac{P}{P_S} < 0{,}17$ (on benzene),

2: $\frac{P}{P_S} \approx 0{,}17 \div 0{,}5$

3: $\frac{P}{P_S} > 0{,}5$

Ism	Sheet	Document №	Sign.	Date		page
Executed		Kholov R.V.				
Head		Tsukanov M.N.				

The adsorption isotherm for the solution of the equations shares on three areas:
1 area - linear dependence between concentration of gas and amount of the absorbed substance and conditionally is accepted that the isotherm of adsorption submits to the law of Henry.
Then adsorption duration:

$$\sqrt{\tau} = \sqrt{\frac{x^*}{\omega_Г \cdot y_н} \cdot \sqrt{H_н{}'} - в} \sqrt{\frac{x^*}{\beta_y \cdot y_н}};$$

where $_{un}$ - initial concentration of the adsorbed substance, kg m^3
x * - equilibrium amount of the adsorbed substance, kg kg (is accepted on an isotherm of adsorption and it is multiplied by the bulk density of adsorbent).

к /$y_н$	,0 05	,01	,03	,05	,10	,2	,3	,4	,5	,6	,7	,8	,9
	,8 4	,67	,35	,19	,97	,67	,42	,23	,0 7	0,10	0,27	0,4 6	0,68

2 area - curvilinear

$$\tau = \frac{x^*}{\omega_Г \cdot y_н}\left\{H_н - \frac{\omega_2}{\beta_y}\left[\frac{1}{P}\ln\left(\frac{y_н}{y_к} - 1\right) + \ln\left(\frac{y_н}{y_к} - 1\right)\right]\right\};$$

$$P = \frac{y_н}{y_1{}^x}$$

where $y_1{}^x$ - the content of substance in a gas stream, equilibrium with the quantity equal to a half of the substance which is most absorbed by adsorbent at this temperature, kg/m^3.
3 area - amount of the substance absorbed by adsorbent reaches a limit and remains to a constant

$$\tau = \frac{x^x}{\omega_Г \cdot y_н}\left\{H_н - \frac{\omega_2}{\beta_y}\left[\frac{1}{P}\ln\left(\frac{y_н}{y_к} - 1\right) + \ln\left(\frac{y_н}{y_к} - 1\right)\right]\right\}, \quad P = \frac{y_н}{y_1{}^x}$$

6) Mass transfer zone height (height of a working layer)

$$h_o = H_н \frac{\tau_{нас} - \tau_{з.д}}{\tau_{нас} - (1 - f_1)(\tau_{нас} - \tau_{з.д})},$$

$\tau_{нас}$ – time before equilibrium saturation, sec.

$\tau_{з.д}$ – time of protective action at the minimum proskokovy concentration,

f_1 – unused adsorptive capacity, $f_1 \approx (0{,}5 \pm 0{,}02)$

7) Differential pressure in a layer (the formula is applicable, if porosity of a layer of E=0,4)

$$\Delta P = \frac{2 H_{н}}{g d_{э} \rho_{Г}} \left(\frac{770\ \mu_{Г} G_{Г}}{d_{э}} + 10.6 G_{Г}^{2} \right)$$

r - differential pressure in a layer, kg/m^3

g - 9,81 m/s^2

de - the equivalent diameter of grains, m

G - mass speed of gas, kg / (m2 s)

Other formulas (author Dubinin)

1) $\Delta P = 168{,}5 \cdot 10^{-5} \cdot \mu_{Г} \left(\omega_{Г} \frac{H}{d_{э}^{2}} \right)$ - at ω_{2} <0,25m/with, the laminar mode

2) $\Delta P = \frac{47{,}97 \cdot 10^{6} \cdot \mu_{Г}^{0{,}15} \cdot \rho_{Г}^{0{,}85}}{\left(H_{н} \cdot \omega_{Г}^{1{,}85} \right) / d_{э}^{1{,}15}}$ - transitional area

3) $\frac{\Delta P}{H_{н}} = \frac{f(\omega_{2} \cdot \rho_{Г})}{2 g d_{э}}$ - in a layer of zeolites

$f = \frac{10.9 \cdot 10^{2}}{(\mathrm{Re}')^{0{,}64}}$ - for spheres, $f = \frac{3.64 \cdot 10^{2}}{(\mathrm{Re}')^{0.5}}$ - for cylinders

$$\mathrm{Re}' = \frac{\omega_{Г} \cdot d_{э}}{\nu}$$

Having substituted the received values in the equation

$$x_{2}^{*} = x_{1}^{*} \cdot \frac{V_{1}}{V_{2}} = x_{1}^{*} \cdot \frac{1}{\beta} = \frac{109{,}0}{1{,}09} = 100 кг / м^{3}$$

Let's express partial pressures through volume concentration on the equation

$$y = \frac{P}{RT}$$

for benzene: $y_{н_1} = \frac{75 мм.рт.ст \cdot 13{,}6 \cdot 9{,}81}{8310 \cdot (273 + 20)} = 0{,}0041 кг / м^{3}$

for the diethyl ether: $y_{н_2} = \frac{442 \cdot 13{,}6 \cdot 9{,}81}{8310 \cdot 293} = 0{,}0242 кг / м^{3}$

$$\lg y_{2}^{x} = \lg y_{н_2} - \beta \frac{T_1}{T_2} \cdot \lg \frac{y_{н_1}}{y_{1}^{*}} = \lg 0.0242 - 1.09 \frac{293}{293} \cdot \lg \frac{0.0041}{0.000854};$$

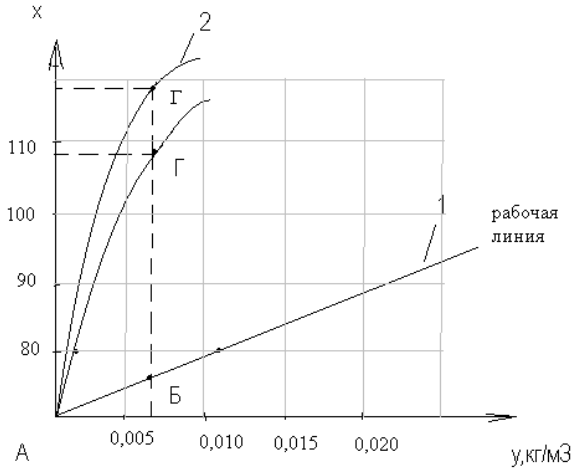
$$y_{2}^{x} = 0{,}004379 кг / м^{3}$$

For other points we make the table and on coordinates of points we build the schedule - an isotherm of adsorption (line 2)

Basic data:

points T	Benzene		Diethyl ether	
	y_{1}^{*}, кг / м	x_{1}^{*}, кг / м	y_{2}^{*}	x_{2}^{*}

1	0,000854	109,0	0,004379	100,0
2	0,00256	134,3	0,0148	123,11
3	0,005125	139,8	0,0308	128,2
4	0,00939	143,0	0,0597	132,19
5	0,017060	147,3	0,1145	135,1
6	0,025610	151,2	0,01786	138,71



Adsorbent volume:

$$V_{ад}' = \frac{V_Г \cdot (y_н - y_к)}{x^* - x_н} = \frac{0{,}555(0{,}006 - 0{,}00003)}{104 - 0} = 3{,}18 \cdot 10^{-5}\, м^3 / с$$

Here x* = i.e. at the exit adsorbent will be completely saturated to the absorbed components (we assume!)
at un=0,006 kg/m^3 according to the schedule xh=104kg/m^3.
We accept the actual amount of adsorbent 30% more

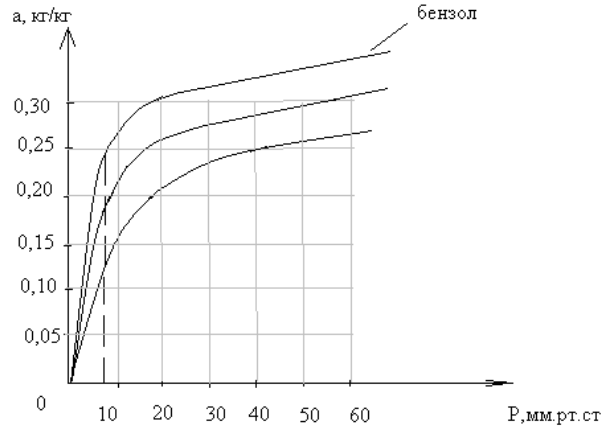
$$V_{ад}' = (3{,}18 \cdot 10^{-5}) \cdot 1{,}3 = 4{,}134 \cdot 10^{-5}\, кг / м^3$$

3. For definition β_y previously we will find

$$\mathrm{Re} = \frac{\omega_Г \cdot d_э \cdot \rho_г}{\mu_Г \cdot E_н} = \frac{0{,}28 \cdot 0{,}0013 \cdot 1{,}21}{0{,}018 \cdot 10^{-3} \cdot 0{,}3} = 61{,}1,$$

since Re> 30, β_y on the equation $N_y' = 0{,}395 \cdot \mathrm{Re}^{0.64} \cdot \mathrm{Pr}^{0.33}$.
Adsorption isotherm

Ism	Sheet	Document №	Sign.	Date		page
Executed		Kholov R.V.				
Head		Tsukanov M.N.				



According to Pavlov:

(.) $a_1^{\ x} = 0{,}25 кг/кг$, to it there correspond P1=8 mm Hg. Let's calculate coordinates corresponding to points on an isotherm of diethyl ether

$a_2^{\ *}(x_2^{\ *}) = a_1^{\ *}(x_1^{\ *}) \cdot \beta$;

$$V_1 = \frac{M_б}{\rho_ж} = \frac{78}{879} = 0{,}0887 м^3 / кмоль$$

$$V_2 = \frac{74}{714} = 0.1036 м^3 / кмоль$$

$$\beta = \frac{V_2}{V_1} = \frac{0.1036}{0.0887} = 1.17$$

$$a_2^{\ *} = a_1^{\ *} \cdot \frac{V_1}{V_2} = \frac{0.25}{78} \cdot \frac{0.0887}{0.1036} = 0.0027 кмоль/кг \cdot 74^к = 0{,}20 кг/кг$$

=>

Diffusion criterion of Prandtl.

$$\mathrm{Pr} = \frac{\mu_Г}{(Д_{20} \cdot \rho_Г)},$$

D20, To - diffusion coefficients

$$Д_{20} = Д_0 \left(\frac{T}{T_0}\right)^{3/2} \cdot \frac{P_0}{P}$$ - for temperature of 20 °C,

and To - at t=0 °C it is equal 0,028 m2/ch=0,0778·10^{-4} m2/sec.

$$Д_{20} = 0{,}0778 \cdot 10^{-4} \left(\frac{293}{273}\right) \cdot \frac{101325}{101325} = 0{,}0864 \cdot 10^{-4} м^2 / сек$$ - for diethyl alcohol

$$\mathrm{Pr} = \frac{0.018 \cdot 10^{-3}}{0.0864 \cdot 10^{-4} \cdot 1.21} = 1.722$$

$Nu' = 0.395 \cdot 61.1^{0.64} \cdot 1.722^{0.33} = 6.5$, and Nu' is in turn equal:

Ism	Sheet	Document №	Sign.	Date		page
Executed		Kholov R.V.				
Head		Tsukanov M.N.				

$$Nu' = \frac{\beta_y \cdot d_э^{\,2}}{Д}$$, then

$$\beta_y = \frac{Nu' \cdot Д_{20}}{d_э^{\,2}} = \frac{6{,}5 \cdot 0{,}0864 \cdot 10^{-4}}{0{,}0013^2} = 33{,}19 c^{-1}$$

4. Height of units of transfer.

$$h = \frac{G_Г}{S_{сл} \cdot \beta_y}$$;

$$G_Г = V_Г \cdot \rho_Г (м^3 / с \cdot кг / м^3)[кг / с]$$

$$S_{сл} = S_a$$

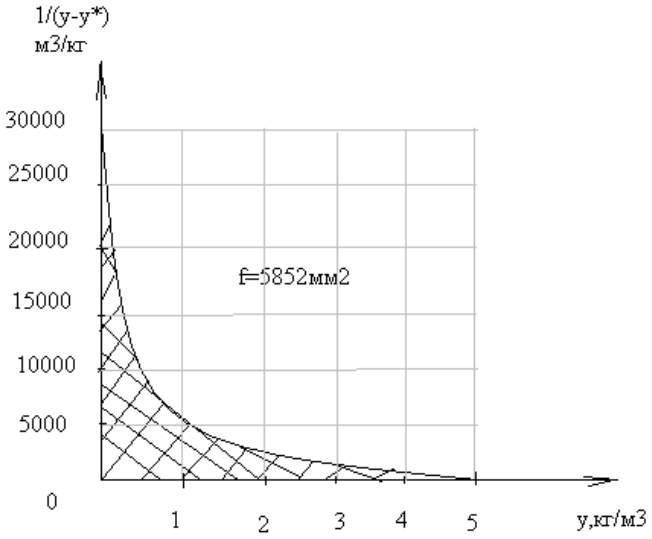
$$h = \frac{(0.555 \cdot 1.21)}{(2.01 \cdot 33.19)} = 0.0101$$

5. We determine number of units of transfer by method of graphic integration. For creation of the working line of transfer (1 line) we find from the equation of a material balance:

$$x_к = \frac{V_Г}{V_{ад}} \cdot (y_н - y_к) + x_н = \frac{0{,}555}{4{,}134 \cdot 10^{-5}} (0{,}006 - 0{,}00003) + 0 = 80{,}23 кг / м^3$$

On coordinates of points hn=0, hk=80,23 and uk=3 10^{-5}, un=0,006 we build the working line of process. We determine sizes for graphic integration by the constructed chart. We are set by a number of at values in an interval $_{un —ук}$and for each at value we find values x * on the working line and value at * on the equilibrium line.

y, kg/kg	x*, kg/m^3	y', kg/m^3	y-y*	1/(y-y*)
0,006	80,23	0,00133	0,00467	214,133
0,005	78,0	0,00125	0,00375	266,666
0,004	75,2	0,00110	0,00290	344,827
0,003	74,0	0,00095	0,00205	487,804
0,002	73,2	0,00085	0,00115	869,56
0,001	71,5	0,0006	0,0004	2500
0,00003	70,0	0	0,00003	33333,33



Scales are defined:

$$M_1 = \frac{l_1}{n_1}, M_2 = \frac{l_2}{n_2}$$

$$M_1 = \frac{333,33}{260} = 128,2 \; M_2 = \frac{0,006}{240} = 0,25 \cdot 10^{-4}$$

$$n_y = \int_{y_к}^{y_н} \frac{d_y}{y - y^*} = f \cdot M_1 \cdot M_2 = 5852 \cdot 128,2 \cdot 0,25 \cdot 10^{-4} = 18,75$$

Adsorbent height:

$$H_н = n_y \cdot h = 0,0101 \cdot 18,75 = 0,19 \approx 0,25 м$$

$$V_{ад} = H_н \cdot S_a = 0,25 \cdot 2,01 = 0,502 \; м$$

6. Duration of process of adsorption is determined by the law of Henry, since (·) un on graphics being in straight line area

$$\sqrt{\tau} = \sqrt{\frac{x^*}{\omega_Г \cdot y_н}} \cdot \sqrt{H_н} - в\sqrt{\frac{x^*}{\beta_y \cdot y_н}}$$

$$\sqrt{\tau} = \sqrt{\frac{104,0}{0,28 \cdot 0,006}} \cdot \sqrt{0,25} - 1,84\sqrt{\frac{104,0}{33,19 \cdot 0,006}} 82,4$$

$$\tau = 82,4^2 = 6780 \approx 113 мин \approx 1,9ч$$

7. Amount of the gas-air mixture passing through adsorbent in time τ

$$V = S_a \cdot \omega_2 \cdot \tau = 2,01 \cdot 0,28 \cdot 6789,76 = 3821,276 м^3$$

or 3821,276 m^3 · 1,9ch =2011,19 m3/h

8. Differential pressure in a layer

$$\Delta P = \frac{2H_н}{gd_э \rho_Г} \cdot \left(\frac{770\mu_Г \cdot G_Г}{d_э} + 10,6 \cdot G_Г{}^2 \right) = \frac{2 \cdot 0,25}{9,81 \cdot 0,0013 \cdot 1,21} \left(\frac{770 \cdot 0,018 \cdot 10^{-3} \cdot 0,334}{0,0013} + 10,6 \cdot 0,334^2 \right) =$$

$$= 116,,5 кг / м^3$$

Ism	Sheet	Document №	Sign.	Date		page
Executed		Kholov R.V.				
Head		Tsukanov M.N.				

where $$G_2 = \frac{V_Г \cdot \rho_Г}{3600 \cdot S_a} = \frac{2000 \cdot 1{,}21}{3600 \cdot 2{,}01} = 0{,}334 кг / м^3 \cdot с$$

4. HEALTH AND SAFETY AND ENVIRONMENTAL PROTECTION

4.1. Labor protection.

The main danger of industrial facilities of oil processing represents an emergency gas contamination, the fires and explosions. Many of products fire and explosion hazardous or toxic. Annually in the world at the oil processing enterprises occurs to 1,5 thousand accidents which 4% carry away a significant amount of human lives. Accident rate tends to growth. Improvement of technology processes and the equipment is an important factor of increase of level of safety of production. The characteristic of production rooms on potential of explosion. The operator category of fire danger of D. Klass on PUE - is not explosive. Pumping Category A. A class on PUE - In - 1a. Territory of installation. Category A. A class on PUE-V-1g.

Characteristic of harmful substances.

1. Carbon monoxide (WITH). Colorless, poisonous, ognevzryvoopasny gas, without taste, with very slight smell. Burns with a bluish flame. PDK-20мг/м^3. Limits of potential of explosion of 13-75% about. Main symptoms: loss of consciousness, otdyshka, asthma.

2. Hydrogen sulfide - H2S. Colorless gas with a smell of rotten eggs. The general nature of action on an organism: the strong nervous poison causing death from respiratory standstill affects airways annoyingly. Maximum concentration limit - 10 mg/m3. Limits of potential of explosion of 4,3-45,5%. Individual protective equipment - the filtering gas mask of brand "B".

3. Fat gas. An aggregate state under normal conditions - gaseous. Density of vapors by air - 1,98.

4. Gasolines. Class of danger 4. The general nature of action on an organism - as drug. Cracking gasoline toksichny straight run gasolines. At concentration of any gasoline of 35000-40000 mg/l are life-threatening even at inhalation of 5-10 minutes. Mg/m3 PDK-100. Side-altar of explosibility of 0,87-8,75%. During the work with gasoline the gas mask of brand "A" is applied.

Actions at labor protection. The foreman makes daily check in divisions of workshop, a condition of protection and a working condition the organization of workplaces, operability of the equipment, correctness of conducting technology process and operations.

The chief of installation makes daily check of workplaces of the equipment, devices, means of collective and individual security, operability of alarm systems and blocking.

Labor protection and safety measures is a complex of the methods developed and directed on health protection and safety of staff of the enterprises in the course of performance of their working duties by them in working hours and also during the work of employees with the different equipment. Labor protection and safety measures is regulated by a row different normative and legal, acts, including the Labour Code of the Republic of Uzbekistan, implementation of this direction is provided with the coordinated combined actions of authorities of the Republic, subjects of authorities of the Republic, local governments, employers, their

associations, labor unions and other authorized officers of representative bodies on labor protection.

Labor protection at the different enterprises is provided with a complex of actions which are directed on an exception or decrease in cases of traumatism, and also on decrease and elimination of risks of emergence of accidents. For this purpose at the enterprise services on labor protection and the persons bearing responsibility for instructing and carrying out training of employees in safety measures and exercising control over implementation of rules and standards of safety which interact with the employer, inspectorate for work and labor unions function.

4.2. Environmental protection.

Social value.

In the middle of our century has sharply become aggravated the problems connected with chemical pollution the biosphere, which are quite often leading to critical toxic and ecological situations. The main sources of pollution of the atmosphere are reservoirs and oil products. Strengthening of installations significantly reduces emissions of harmful substances in the atmosphere.

Waste and emissions.

1. The fulfilled alkali solution. It is formed constantly. The fulfilled solution of alkali is recycled on the SShchS installations. Number of 300 tons/year.

2. Waste oils. Waste oils are taken away on installation of regenerations of oils. Drain waters from the cooling pumps go to biological cleaning of UVK and OSV. A dumping place in the industrial sewerage after local cleaning.

Actions for protection environments.

Actions for reduction of emissions at the mode 1:

1. Strengthen control of exact observance of the technical mode according to technology regulations.

2. Forbid work of the equipment on the forced mode.

3. Strengthen control of work of processing equipment, shutoff valves, PILES and A devices.

4. Stop a purge, steaming, cleaning of the equipment and repair works, coherent with raised allocation of harmful substances the atmosphere. Emissions of all on workshop with actions of 130,205 g/sec.

4.3. Requirements for safety measures

The safety measures are a complex of actions of organizational and technical character which are directed on creation of safe working conditions at the enterprise, allowing to lower or exclude operational injuries. For this purpose check operability of the operative equipment, defensors to machines, machines, heating installations. Optimize for the purpose of safety of a working condition, providing good illumination of workplaces and production rooms, good ventilation, timely removal of dust and production wastes, maintenance of normal temperature in rooms. By the person responsible for performance of safety conditions of work at the enterprise, it is instructed by safety regulations at the enterprise in general and during the work with the specific equipment, training of the personnel and examination about safety rules. Also labor protection at the enterprise includes providing the personnel with safety rules, equipment of workplaces with posters and visual aids on work with the equipment and images visualizing the most dangerous places on production and the actions preventing operational injuries.

Requirements for safety measures to the staff of the enterprise

To lower operational injuries, employees are also obliged to adhere to certain requirements and rules of behavior on a workplace which are provided by safety measures:

- put on overalls which should be in a full order, and also working footwear;
- before work to prepare a workplace, to release it for work, to check illumination and operability of the equipment;
- be convinced that the floor on a workplace in operability, does not slide, and is not present on a floor of foreign subjects about which it is possible to stumble;
- during an operating time with a specific type of the equipment to use defensors - gloves, points, grids and others;
- not bend it is closely to the working equipment and use flow charts.

Basic rules of safe conducting technology process

Implementation of the following rules of safe conducting process, the related works excludes possibility of accident, explosions, the fires, traumatizing people, violation of the technology mode.

The persons allowed to production of works should be instructed and trained in safe working methods, pass examinations and have at themselves the corresponding certificate. At introduction of new technology processes and methods of work, types of the equipment and mechanisms, and also rules and instructions, additional instructing should be carried out.

Blocking up and pollution of production sites, rooms, the equipment, drives, roads in places is not allowed where should be prohibited journey of transport precautionary texts and signs are hung out, drainage and sewer wells should be reliably closed or protected.

Systematically survey and check of a production equipment and its timely repair according to the schedule of PPR should be made. Each operative

equipment, devices, vessels should be equipped with a complete set of adaptations, the devices provided by the project or state standard specification.

Work of a production equipment with violation of the parameters established by the flow chart or technology conditions and instructions is not allowed.

Changes are allowed to be made to the flow chart (regulations) only after written instructions of the chief engineer of the enterprise, and they should correspond to the working parameters specified in the passport of the equipment.

Operation of pipelines, the equipment, devices, vessels at not tightness of flanged couplings or cracks on the whole material - is forbidden, carrying out on them any repair work during their work is also not allowed.

Production rooms should be provided with the ventilation creating the condition of air environment meeting sanitary standards in a zone of stay of workers. Efficiency of ventilation units is checked systematically, once a year. At a forced stop of ventilation units measures for providing a sanitary condition of air environment, according to sanitary standards CONSTRUCTION NORMS AND REGULATIONS should be taken.

Special instructions on the measures taken by the personnel at a sudden gas contamination or emergence of the fire are listed in operating manuals of ventilation units.

In order to avoid distribution of the fire to networks of the stormwater sewerage during ignition of oil products or the fire on a production site, on sewer networks of promstok and production and storm drains water locks are established.

Power supply facilities should be serviced by the electrotechnical personnel having the relevant group of the admission. Tension on electric equipment should move and be removed the person on duty electro - the personnel according to the indication of this equipment, responsible for operation, or the senior on change. At emergence of the fire on electric equipment stress should be immediately removed.

Warming of the equipment and pipelines in winter time can be made only by steam or hot water.

The safety armature on devices should conform to the imposed requirements "Rules for the Construction and Safe Operation of the devices working under pressure".

Start-up and work of installation with a faulty fire extinguishing system is forbidden.

All constructions of installations, depending on category, should be reliably grounded by means of grounding devices from direct strokes, secondary manifestations of a lightning and static electricity.

The equipment, subject to opening and repair, should be brought out of work, is exempted from a product, deafened, steamed, washed out by water and aired. All bringing pipelines to the repaired equipment should be deafened. Washing with water of not cooled down equipment it is inadmissible. Works on the disconnected equipment and the pipeline, are allowed only on obtaining the

analysis of gas-air mixture. Works on cleaning of the equipment of devices, vessels from slime should be made only in hose gas masks with the doubler crew not less than 2 persons. Lamps in explosion-proof execution should be used to internal lighting of the device, a vessel, with tension it is not higher than 12B.

The admission to gas dangerous works of the persons which are not trained in safe methods of conducting works, ways of rendering the first pre-medical aid to victims is forbidden.

Gas dangerous works should be performed only in the presence the order admission and in the presence of responsible for carrying out gas dangerous works.

It is necessary to conduct a constant control behind a condition of gas environment, immediately to stop work at a gas contamination above admissible concentration.

Before the admission to work on service of blocks of reagent-deemulgatora the service personnel should be instructed and acquainted with instructions of safety of work. The works connected with chemical reagent should be made strictly in the overalls protecting a body, hands, feet.

CONCLUSIONS.

For the purpose of increase in production of liquefied hydrocarbon gas construction on the basis of "Shurtanneftegaz" of a complex on production of SUG is provided in the program of development of the oil and gas industry of the republic for 2003-2010, using the available opportunities and the saved-up practical experience. The complex from four installations is offered. As the basic the considered UPBS-3 with a productivity of 3 mlrd.st.m3/year is accepted above. On three new installations (three blocks) projects of the equipment UPBS-3 are as much as possible used. Technology process is improved taking into account the implemented changes and modernization on this installation. Gas of 9 billion m will be supplied to three lines after zeolitic blocks of desulphurization^3 in a year. Implementation of this project will allow to receive according to preliminary data in addition in a year 135 thousand tons of propane-butane mixture and 51 thousand tons of gas condensate.

Besides, as a matter of experience operation of UPBS-3, use of the turboexpander unit is projected on Mubareksky GPZ at implementation of the project of processing natural and torch (passing, aerations, stabilization and deethanizings) field gases Kokdumalak (4 billion m3/year) with production of liquefied hydrocarbon gas and gas condensate. Gases fields Kokdumalak are characterized by the high contents propane - butane fractions and have the following structure (% about.): in flare gases after compression (MPa P=5,7) $_{\text{of CH4}}$ = $_{\text{78,90, C2H6}}$ = $_{\text{9,45, C3H8}}$ = 3,50, $_{\text{i-C4H10}}$ = 0,43, $_{\text{n-C4H10}}$ = $_{\text{1,26, C5+B}}$ = 1,57, H2S = $_{\text{0.09, N2}}$ = $_{\text{0,99, CO2}}$ = 3,81; in free gas with the GPP (Rotb. = 5,7 MPas, Totb. = 38-41 0C) $_{\text{CH4}}$ = 89,81; $_{\text{C2H6}}$ = 3,41; $_{\text{C3H8}}$ = 1,80; $_{\text{i-C4H10}}$ = 0,20; $_{\text{n-C4H10}}$ = 0,44; $_{\text{C5+B}}$ = 0,31; H2S = 0,08; $_{\text{N2}}$ = 0,97; $_{\text{CO2}}$ = 2,98. $_{\text{C3 potential}}$ + $_{\text{C4}}$ in free gas of a field Kokdumalak makes about 2,3-2,4% about.; the associated petroleum gases and gases of aeration, stabilization and deethanizing from installations of preparation of gas condensate having rather low pressures and burned now on torches contain C3 + C4 from 2,3 to 5% about.

Proceeding from it, for increase in production of liquefied gas in the republic the decision to collect, prepare and skomprimirovat flare gases of a field Kokdumalak up to the pressure of 5,7 atm is made. the multi-stage compressor and together with free gas with a total amount of 4 billion m^3 in a year on the separate gas pipeline to direct on Mubareksky GPZ. Here the cleared and drained gas after the block of zeolitic cleaning is supplied to installation of receiving liquefied hydrocarbon gas. Kokdumalak is going to compensate natural gas of a field a gas supply from the field Alan having rather low maintenance of C3 + C4 (to 1,2% about.).

Further on Mubareksky GPZ it is offered to construct two more similar installations which will recycle low-sulfur natural gases as fields Kokdumalak, and fields Alan, Zevarda, Pamuk, Kultak with the following average their structure (% about.): $_{\text{CH4}}$ = 90,0; $_{\text{C2H6}}$ = 3.66; $_{\text{C3H8}}$ = 0,85; $_{\text{i-C4H10}}$ = 0,16; $_{\text{n-C4H10}}$ =

0,24; $_{C5+B}$ = 0,23; H2S = 0,07; $_{N2}$ = 0,49; $_{CO2}$ = 4,3. Potential $_{of\ C3+C4}$ makes 1,25% about.

Predesigns show that on the specified MGPZ installations it is possible to receive 300-250 thousand tons of PBF, 100-70 thousand tons of gas condensate in a year.

Thus, in the republic there is a real possibility of increase in output of SUG to 600 thousand tons a year which will allow to expand a network of the cars working at SUG to increase the volume of export of this type of products and will promote development of the gas-chemical industry.

Considering availability of natural gas reserves in the republic, one more perspective direction of its use is receiving the synthetic liquid fuel (SLF). From natural gas many leading firms, such as Exxon Mobil, in Sasol Chevron, Syntroleum Corp, Conoco, Cros Solutions, Lurgi Oil-Gas-Chemic are engaged in the production technology of SZhT. Gmbh and others. According to the technology scheme of production of SZhT natural gas (metane fraction) is oxidized in the presence of the catalyst in the synthesis gas containing CO and H2, further or in the course of Fischer-Tropsh turns into motor fuel, or using process Mobile - through intermediate receiving methanol turns into gasoline. Thus from 1m^3 synthesis gas is received by 120-180 g of synthetic gasoline, and its cost in comparison with the gasoline made from oil, 1,8-3,7 times more expensively. Further development of the production technology of SZhT is directed on increase of efficiency by use of cheaper catalysts and reduction of cost value of products.

The Uzbek Oil and Gas Research and Design Institute of the Republic of Uzbekistan studies experience of the leading firms in the field of production of SZhT and carries out technical and economic calculations whenever possible of application of the production technology of SZhT in the short term in the Republic of Uzbekistan.

Development of technology of deep gas refining in Uzbekistan will allow to increase production of low-toxic motor fuels, to compensate gradual reduction of production of gasoline from oil, to pave the way for development of petrochemistry and in the long term from gas to receive low-toxic synthetic fuels.

Secondary processing of oil and gas feed stock has received nowadays the name of petrochemical synthesis. Already now 25% of world chemical products are issued on the basis of oil and hydrocarbon gases. The near-term outlook of development of the petrochemical industry is exclusively favorable as in terms of the scope of productions, and on a boundless variety of the intermediate and final products of synthesis.

Treat petrochemical products: plastics, synthetic rubbers and pitches, synthetic fibers, synthetic detergents and surface-active substances, some chemical fertilizers, additives to fuels and oils, synthetic lubricating oils, proteinaceous and vitamin concentrates, numerous individual organic substances: alcohols, acids, aldehydes, ketones, hlorproizvodny ethers, glycols, polyglycols, glycerin and others, applied in the industry, agriculture, medicine and in life.

All aforesaid fully belongs to oil refining problems in Uzbekistan. In modern civil and military aviation the propulsion jet engines (PJE) working nazhidky hydrocarbon fuel were widely used. It is caused by rather wide resources of oil hydrocarbon fuels, their sravnitelnonevysoky cost, high power pokazatelyamiya some other advantages.

Application of VRD which is at the same time the airplane propulsion unit without difficult mechanical transfer and running devices allows to create big draft with rather small weight, and unlike piston engines with the propeller pulling force of VRD not only does not decrease with increase in height and flying speed, on the contrary, even increases. Improvement of VRD and reactive airplanes has always been directed on further increase in height and flying speeds, increase of motor potential, reliability and profitability of engines, obespecheniyebezopasnost of flights. In dependence otrazvivayemy speeds and heights of flight it is accepted to classify VRD and according to a toplivan two types: for subsonic and supersonic reactive airplanes.

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