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Efficient Use of Low-Pressure Low-Sulfur Deposits

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ABSTRACT: The adsorbent choice in the acid gases purifying process using zeolite mainly depends on the composition, gas pressure and temperature. The adsorber design and the heat exchangers efficiency are also important. The adsorbent choice for the low-sulfur gases purification is investigated using a simulation system.

I.INTRODUCTION

Natural gas produced from low-pressure gas fields can be effectively used by preventing pressure losses during transportation, purification and dehydration using a zeolite dehydration and gas purification unit (ZD&GPU) for the local population or industrial consumers near the gas field.

For the ZD & GPU design construction in low-pressure fields, the GDIand GCS work is initially performed

Gas-dynamic studies of wells

1. Downhole pressure measurement.

Research is carried out at the wells of the producing fund.Downhole parameters are measured to assess the actual well operation. When registering parameters with a given step in depth (plot) or when using a position and velocity sensor, the phase distribution uniformity in the wellbore is determined.

2. Measurement of reservoir pressure.

The study is carried out both at the production and piezometric well stock in order to assess the field development state, and at exploratory wells in order to determine the initial parameters of the penetrated formation.When registering parameters with a given step in depth (plot) or when using a position and velocity sensor, the phase distribution in the wellbore is determined.

3. Gas-dynamic research (complex).

Research under stationary filtration modes.

The study is carried out in conjunction with the study on non-stationary filtration modes (PBC, PDC). The well is being operated in several modes.

Studies under non-stationary filtration modes. To assess the true skin factor, the bottom hole pressure decay (PDC) curve is recorded at each mode. To determine the reservoir parameters, the pressure build-up curve is recorded(PBC).

Field gas condensate studies (GCS).

Produced in one or more stationary modes. Formation gas is separated into two phases using a gas separator - gas and liquid. Each phase is measured. Samples are taken from each phase. The water cut of the well product is determined.

Gas condensate studies can be carried out both by the traditional method using conventional measuring gas separators, in which the gas flow rate is determined using the DIKT and burned in a flare, and the liquid flow rate is determined by the volumetric method, and using modern gas condensate plants equipped with high-precision flow meters (for gas and liquid), which allows you to work in a collection loop without losses (without gas burning).A primary report is drawn up based on the field gas condensate studies results, the results which are the initial data for analytical and laboratory studies.

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The following work types are carried out within the engineering support framework for GDI and GCS:

- selection of the optimal research technology;
- research design (design);
- drawing up a work plan;
- control of the entire research process;
- comprehensive interpretation of the received field data and a detailed report on the work done.

Based on the results of GCS and GDI, design is carried out for the productive composition of a gas or gas condensate field.

ZD & GPU is designed for dehydration and purification of natural gas to the required moisture dew point temperature and its purification from hydrogen sulfide-containing compounds, as well as from mechanical impurities.

It is desirable to use CaA grade zeolite in ZD & GPU. The advantage of CaA is that it not only provides the gas dew point, but also removes hydrogen sulfide from natural gas.

A. Initial data for design

A.1 Physicochemical properties of the gas-condensate mixture of a pilot field

Table 1 shows the composition of the feed gas for the pilot field:

Mole components.%	Experimental field
	XV-г
1. Molar fraction of the component of the produced gas, %	
CH_4	92,299
C_2H_6	3,57
C_3H_8	1,25
изо-C_4H_{10}	0,27
н-C_4H_{10}	0,26
изо-C_5H_{12}	0,13
н-C_5H_{12}	0,11
$C_6H_{14+в}$	0,13
N_2	0,72
CO_2	1,26
H_2S	0,001
Total	100
2.Gas moisture content *, g/m^3	13,0

*- Calculated moisture content of gas according to the nomogram of equilibrium content of water vapor in natural gas.

1.2 Production capacity of the facility

For the detailed design development, the (projected) unit capacity for the purification and dehydration of natural gas is in the range:

- natural gas – from $20\times10^3 m^3/d \div 50\times10^3\ m^3/d$;

The gas purification calculation and drying process was made for $16,6\times10^6 m^3/y$ ($50\times10^3 m^3/d$) gas productivity (the fund of working time efficiency was taken as 8000 hours per year).

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B. Technical characteristics of working substances
B.1 Feed gas:

The parameters of the gas supplied to the installation are:
- pressure – 16 bar (абс.);
- temperature – 40 °C.

2.2 Finished products

On ZD & GPU they get:
- purified and dried gas;
- liquid phase (condensate + water).

Dried and cleaned gas at the projected plant must comply with the requirements of SS 5542 "Combustible natural gases for industrial and municipal purposes". [1]

Dried and cleaned gas parameters at the outlet ZD&GPU:
- pressure – 8÷13 bar (abs.);
- temperature – 40÷50 °C.

The liquid released during the natural gas preparation is taken out by road for further preparation.

The calculated component composition and physicochemical characteristics of the purified and dried gas at the outlet of the projected ZD & GPU are presented in Table 3.

Table 3-Calculated component composition and physicochemical characteristics of the purified and dried gas at the outlet of the designed ZD&GPU

Indicator name	Value
1. Molar fraction of components, %	
CH_4	92,01
C_2H_6	3,57
C_3H_8	1,25
изо-C_4H_{10}	0,27
н-C_4H_{10}	0,26
$C_{5+в}$	0,64
N_2	0,72
CO_2	1,26
H_2S	0,000
H_2O	0,01
Total	100
2. Density at 20 °C and 760 mm Hg, kg/m^3	0,7642
3. Relative molecular weight	18,02
4. Gas moisture content *, g/m^3	0,098

B.2 Supporting materials

Compressed air

Compressed air is intended for testing instruments and automation equipment of the pneumatic control and regulation system, maintaining the specified parameters of the working media for the purpose of stable and trouble-free operation of the installation.

Reagents

For drying gas from moisture and purification from hydrogen sulfide-containing compounds on the projected ZD & GPU, it is recommended to use a synthetic zeolite of the CaA (5A) type of imported or domestic production, silica gel(aluminum oxide Al2O3). Synthetic zeolites are aqueous crystalline aluminosilicates. The synthetic zeolite particles shape can be cylindrical or spherical.Zeolites, having a microporous homogeneous pore structure, exhibit molecular sieve properties in the adsorption process, which is very important for selective separation by components with similar properties.The color of synthetic zeolite is white with a grayish tint. The technical characteristics of type 5A zeolites used at the designed USOG are shown in Table 4.

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Fuel gas

To heat the gas, the heat of the flue gases obtained by burning fuel gas in the P-1 furnace is used.Part of dried and purified natural gas is used as fuel gas, which is fed to the P-1 regeneration gas heating unit.

Table 4

The name of indicators	Units	Value according to the normative document
Synthetic CaA-5A zeolites and CaA zeolites purchased by import with characteristics that correspond to the TU results of the incoming quality control of zeolites		ТУ 38-110231-83
The form The size	mm	Extrudate, ball 1,6; 3,2
Crystallinity degree, not less	%	75
Microscope, shape and size of crystals	мкм	correct shape 2-4
Bulk weight, not less	g/cm^3	0,7
Total pore volume, not less	cm^3/g	0,34
Crushing strength, not less than abrasion by the layer surface, not more than average, not more	kg/mm^2 % ·мин	1,5 1,0 0,5
Statistical capacity by pairs H_2O	10^{-3} g/m^3	180-200
Dynamic capacitance by pairsH_2O, not less н-C_7H_{16}, no more	10^{-3} g/m^3	115 55
Chemical composition , SiO_2 AL_2O_3 Fe_2O_3 CaO, not less Na_2O K_2O	%	12,5 0,5
Reaction rate constant H_2S+CO_2 K 10^{-4} no more	mol/g·c atmosphere	3

C. Description of the technological process and scheme

C.1 Description of the technological process of gas purification and drying with zeolites

Dehydration and purification of gas by the adsorption method is based on the selective extraction of moisture and hydrogen sulfide-containing compounds by solid absorbers - adsorbents.The choice of the grade of the adsorbent is dictated by the size of the cross section of the molecules to be removed from the mixture.Molecules of water vapor and hydrogen sulfide-containing compounds, having an effective diameter commensurate with the pore diameter of the adsorbent, penetrate into the pores and are retained there due to the forces of intermolecular interaction.Raw gas preparation for dehydration is carried out on the existing gas pretreatment unit (SPU), which consists of inlet separators (S-1/1, 2/1), formation water degasser (D-2/1), liquid tanks (L- 1/1, 1/2).Gas dehydration and purification is carried out in vertical cylindrical apparatuses filled with an adsorbent at a pressure of 11-16 bar, a temperature of 40-50°C.A layer of silica gel is provided to prevent the dropping liquid dripping. As the adsorbent pores are filled with adsorbed molecules, its absorption capacity decreases.The absorption capacity recovery of the adsorbent - regeneration, is carried

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out periodically, heated to a temperature of 320°C with a process gas, and cooling - with a process gas with a temperature of 40 ÷ 50°C.

Figure 1 shows a schematic flow diagram of the projected zeolite drying and gas purification unit.The proposed technological solutions provide for the production of gas dried to the moisture dew point temperature and purification according toSS 5542.[1]

In accordance with the adopted technology, the projected production includes*:

- inlet separators S-1/1, S-2/1;
- separatorS-3/1;
- flare separator FS;
- dry and clean gas filter F-1;
- adsorbers A-1, A-2, A-3;
- heat exchanger H-1;
- regeneration gas heating furnace P -1;
- containers for liquid L-1/1 and L-1/2;
- auxiliary equipment.

At the exit from the ZD & GPU, it is necessary to provide for the measurement and monitoring of the moisture content of the dried gas (in-line gas moisture analyzer).The regeneration and cooling of the adsorbent is carried out with process gas taken from the main gas stream after the adsorber.The process gas (cooling gas) is fed back to the cooled adsorber (from bottom to top).

The cooling gas, after the adsorber, is discharged into the regeneration gas collector and (through the tube space of the T-1 heat exchanger (for preheating)) is directed to the P-1 furnace coil.The gas heated in the coils of the P-1 furnace enters the regeneration gas collector and is returned to the adsorber to be regenerated.

Having passed through the adsorber, the gas is saturated with water vapor and hydrogen sulfide-containing compounds and is fed into the shell space of the T-1 heat exchanger, into the tube space of which the cooling gas is supplied.Next, the cooled regeneration gas is fed to the flare separator FS, where the dropping liquid (condensed as a result of cooling in the T-1 heat exchanger) is extracted.Regeneration gas from FS separator is directed to low pressure torch (LPT).In the future, for the rational use of hydrocarbon resources, it is recommended to prepare the regeneration gas and send it to the field's own needs, with the generation of electricity.The liquid phase separated from the FS is sent to the degasser D-2/1.

The liquid released in the separators S-1/1, S-2/1 and S-3/1 is sent to the D-2/1 degasser, where it is degassed at a pressure of 1.6 bar (abs.).The evolved gas is fed to the low pressure torch (LPT).The liquid is sent to containers L-1/1 and L-1/2 for storage. As the container is filled, the liquid is taken out by auto export.

C.2 Calculation of the gas purification and drying process

The calculation of the gas purification and drying process is based on the gas performance $16,6\times10^6 m^3/y$ ($50\times10^3 m^3/d$) (working time efficiency fund adopted 8000 hours per year) according to the composition and parameters of the gas given in Table 1.

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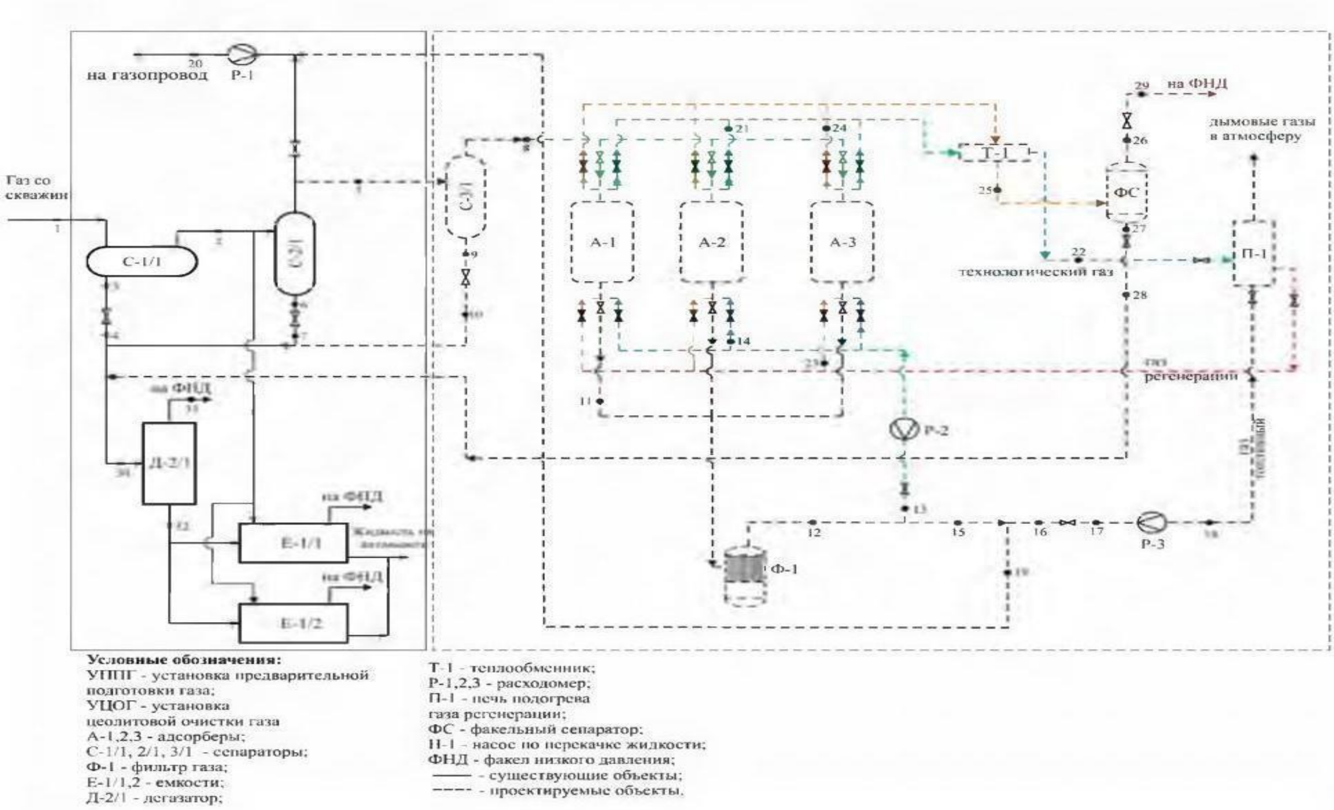

Условные обозначения – Legend
Установка предварительной подготовки газа- Gaspretreatmentunit
расходомер- flowmeter
теплообменник- heatexchanger
Установкацеолитовойочисткигаза - Zeolitegascleaningunit
печьподогревагазарегенерации- regeneration gas heating furnace
Адсорберы- Adsorbers
факельныйсепаратор- flareseparator
Сепараторы – Separators
насоспоперекачкежидкости- liquidtransferpump
Фильтргаза - Gasfilter
факелнизкогодавления- lowpressuretorch
Дегазатор – degasser
Проектируемые объекты- Designed objects
существующие объекты- existing facilities

Figure 1 - Schematic diagram of a gas pretreatment unit and a zeolite drying and gas purification unit.

The pressure at the inlet to the unit is assumed to be 16 bar (abs.), temperature - 40°C.Potential condensate content in the produced gas, taken according to the results of gas condensate studies of a well in a pilot production field (Appendix D), - up to 26,3 g/m^3. Hydrogen sulfide content is 0.001% mol.

The adsorption unit consists of three adsorbers, one of which is on adsorption, one on regeneration and one on cooling.

Each adsorber carries out a cycle consisting of the following sequential stages:

- adsorption (absorption) of water vapor and other polar (hydrogen sulfide) compounds on the zeolite surface until full saturation;
- regeneration of the zeolite by removing the absorbed impurities by flushing with hot process gas;
- cooling the zeolite with cold process gas.

The technological parameters of the process (by equipment and flows) with material flows and heat balance are presented in Figure 1 and Table 5.

The duration of the adsorption cycle in the adsorber is 4 h, regeneration – 4 h, cooling – 4 h. General cycle – 12 h. The cyclogram of the adsorption gas drying and purification process is shown in Figure 2.

The volume of regeneration and cooling gas (process gas) is2,293×10^6 m^3/y (286,7 m^3/h),taking into account the

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operation of the installation 8000 h.

Часы работы	A-1	A-2	A-3
4	**A**	**P**	**O**
8	**P**	**O**	**A**
12	**O**	**A**	**P**
16	**A**	**P**	**O**
20	**P**	**O**	**A**
24	**O**	**A**	**P**

Figure 2 - Cyclogram of the adsorption gas drying process.
A - adsorption; O - cooling; P - regeneration.

Table 5 - Technological parameters of the process (by equipment and flows) with material flows and heat balance

The name of indicators		Item number in figure 1											
		1		**2**		**3**		**4**		**5**		**6**	
Temperature, °C		40,0		39,8		39,8		39,7		39,6		39,6	
Pressure, bar		16,0		15,7		15,7		1,6		15,3		15,3	
Content of components, %		Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.
CH_4		90,44	80,26	91,58	81,51	0,28	0,20	0,28	0,20	91,58	81,51	6,38	0,89
C_2H_6		3,51	5,84	3,55	5,93	0,05	0,07	0,05	0,07	3,55	5,93	1,16	0,30
C_3H_8		1,23	3,00	1,24	3,04	0,06	0,11	0,06	0,11	1,24	3,04	1,29	0,49
iC_4H_{10}		0,26	0,82	0,26	0,83	0,03	0,07	0,03	0,07	0,26	0,83	0,63	0,32
nC_4H_{10}		0,27	0,85	0,27	0,87	0,04	0,10	0,04	0,10	0,27	0,87	0,88	0,44
$C_{5+higher}$		0,68	3,44	0,64	3,15	3,86	21,83	3,86	21,83	0,64	3,15	89,35	97,46
CO_2		1,24	3,02	1,25	3,06	0,02	0,03	0,02	0,03	1,25	3,06	0,21	0,08
H_2S		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
N_2		0,72	1,10	0,72	1,11	0,00	0,00	0,00	0,00	0,72	1,11	0,02	0,00
H_2O		1,68	1,67	0,49	0,49	95,67	77,58	95,67	77,58	0,49	0,49	0,09	0,01
Total		100	100	100	100	100	100	100	100	100	100	100	100
Expenditure	mol/h	88,1		87,0		1,1		1,1		87,0		0,0	
	kg/h	1592,8		1568,3		24,4		24,4		1568,3		0,0	
	st. m^3/h	2083,3		2057,3		0,0		0,0		2057,3		0,0	
Relative molecular weight		18,08		18,02		22,22		22,22		18,02		115,32	
Density in st. con., kg/m^3		0,767		0,764		962,247		962,247		0,764		713,126	
Molar fraction of steam		0,99		1,00		0,00		0,00		1,00		0,00	
Volumetric expenditure mixture, m^3/h in working conditions.		136,6		139,5		0,0		0,1		142,5		0,0	
Mixture density kg/m^3 (in wor. cond.)		11,7		11,2		907,1		258,1		11,0		657,4	
Mixture viscosity, cP (in wor. cond.)		-		0,012		0,968		-		0,012		0,467	
Enthalpy of the mixture kcal/kg		-1098,5		-1068,1		-3049,5		-3049,5		-1068,1		-514,9	
DNP on the raid, bar (37,8 °C)		-		-		2,799		2,799		-		2,713	

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Continuation of table 5

The name of indicators		Item number in figure 1											
		7		8		9		10		11		12	
Temperature, °C		38,0		39,5		39,5		37,9		44,1		43,8	
Pressure, bar		1,6		15,0		15,0		1,6		14,0		13,5	
Content of components, %		Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.
CH_4		6,38	0,89	91,58	81,51	6,28	0,87	6,28	0,87	92,02	81,90	92,02	81,90
C_2H_6		1,16	0,30	3,55	5,93	1,14	0,30	1,14	0,30	3,57	5,96	3,57	5,96
C_3H_8		1,29	0,49	1,24	3,04	1,27	0,49	1,27	0,49	1,25	3,06	1,25	3,06
iC_4H_{10}		0,63	0,32	0,26	0,83	0,62	0,31	0,62	0,31	0,26	0,84	0,26	0,84
nC_4H_{10}		0,88	0,44	0,27	0,87	0,87	0,44	0,87	0,44	0,27	0,87	0,27	0,87
$C_{5\text{-higher}}$		89,35	97,46	0,64	3,15	89,50	97,50	89,50	97,50	0,64	3,17	0,64	3,17
CO_2		0,21	0,08	1,25	3,06	0,21	0,08	0,21	0,08	1,26	3,08	1,26	3,08
H_2S		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
N_2		0,02	0,00	0,72	1,11	0,02	0,00	0,02	0,00	0,72	1,12	0,72	1,12
H_2O		0,09	0,01	0,49	0,49	0,09	0,01	0,09	0,01	0,01	0,01	0,01	0,01
Total		100	100	100	100	100	100	100	100	100	100	100	100
Expenditure	mol/h	0,0		87,0		0,0		0,0		86,6		86,6	
	kg/h	0,0		1568,3		0,0		0,0		1560,8		1560,8	
	st. m^3/h	0,0		2057,3		0,0		0,0		2047,5		2047,5	
Relative molecular weight		115,32		18,02		115,52		115,52		18,02		18,02	
Density in cr. con., kg/m^3		713,126		0,764		713,316		713,316		0,764		0,764	
Molar fraction of steam		0,08		1,00		0,00		0,08		1,00		1,00	
Volumetric expenditure mixture, m^3/h in wor.con.		0,0		145,7		0,0		0,0		158,3		164,2	
Mixture density kg/m^3 (in wor. con.)		78,8		10,8		657,7		80,4		9,86		9,51	
Mixture viscosity, cP (in wor. con.)		-		0,012		0,469		-		0,012		0,012	
Mixture enthalpy kcal/kg		-514,9		-1068,1		-514,8		-514,8		-1055,2		-1055,2	
DNP on the raid, bar (37,8 °C)		2,713		-		2,667		2,667		-		-	

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Continuation of table 5

The name of indicators		Item number in figure 1											
		13		14		15		16		17		18	
Temperature, °C		43,8		43,6		43,8		43,8		43,6		37,7	
Pressure, bar		13,5		13,0		13,5		13,5		13,0		1,1	
Content of components, %		Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.
CH_4		92,02	81,90	92,02	81,90	92,02	81,90	92,02	81,90	92,02	81,90	92,02	81,90
C_2H_6		3,57	5,96	3,57	5,96	3,57	5,96	3,57	5,96	3,57	5,96	3,57	5,96
C_3H_8		1,25	3,06	1,25	3,06	1,25	3,06	1,25	3,06	1,25	3,06	1,25	3,06
iC_4H_{10}		0,26	0,84	0,26	0,84	0,26	0,84	0,26	0,84	0,26	0,84	0,26	0,84
nC_4H_{10}		0,27	0,87	0,27	0,87	0,27	0,87	0,27	0,87	0,27	0,87	0,27	0,87
$C_{5\text{-higher}}$		0,64	3,17	0,64	3,17	0,64	3,17	0,64	3,17	0,64	3,17	0,64	3,17
CO_2		1,26	3,08	1,26	3,08	1,26	3,08	1,26	3,08	1,26	3,08	1,26	3,08
H_2S		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
N_2		0,72	1,12	0,72	1,12	0,72	1,12	0,72	1,12	0,72	1,12	0,72	1,12
H_2O		0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Total		100	100	100	100	100	100	100	100	100	100	100	100
Expenditure	mol/h	12,1		12,1		74,5		1,5		1,5		1,5	
	kg/h	218,5		218,5		1342,3		27,6		27,6		27,6	
	st. m^3/h	286,7		286,7		1760,9		36,2		36,2		36,2	
Relative molecular weight		18,02		18,02		18,02		18,02		18,02		18,02	
Density in st. con., kg/m^3		0,764		0,764		0,764		0,764		0,764		0,764	
Molar fraction of steam		1,00		1,00		1,00		1,00		1,00		1,00	
Volumetric expenditure mixture, m^3/h в wor.con.		23,0		23,9		141,2		2,9		3,0		35,9	
Mixture density kg/m^3 (in wor. con.)		9,51		9,15		9,51		9,51		9,15		0,77	
Mixture viscosity, cP (in wor. con.)		0,012		0,012		0,012		0,012		0,012		0,012	
Mixture enthalpy kcal/kg		-1055,2		-1055,2		-1055,2		-1055,2		-1055,2		-1055,2	
DNP on the raid, bar (37,8 °C)		-		-		-		-		-		-	

Continuation of table 5

The name of indicators		Item number in figure 1											
		19		20		21		22		23		24	
Temperature, °C		43,8		43,6		43,6÷320		195,0		320,0		319,7÷40	
Pressure, bar		13,5		13,0		12,0		11,5		10,5		9,5	
Content of components, %		Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.
CH_4		92,02	81,90	92,02	81,90	92,02	81,90	92,02	81,90	92,02	81,90	88,97	79,18
C_2H_6		3,57	5,96	3,57	5,96	3,57	5,96	3,57	5,96	3,57	5,96	3,45	5,76
C_3H_8		1,25	3,06	1,25	3,06	1,25	3,06	1,25	3,06	1,25	3,06	1,21	2,96
iC_4H_{10}		0,26	0,84	0,26	0,84	0,26	0,84	0,26	0,84	0,26	0,84	0,25	0,81
nC_4H_{10}		0,27	0,87	0,27	0,87	0,27	0,87	0,27	0,87	0,27	0,87	0,26	0,84
$C_{5\text{-higher}}$		0,64	3,17	0,64	3,17	0,64	3,17	0,64	3,17	0,64	3,17	0,62	3,06
CO_2		1,26	3,08	1,26	3,08	1,26	3,08	1,26	3,08	1,26	3,08	1,22	2,98
H_2S		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01
N_2		0,72	1,12	0,72	1,12	0,72	1,12	0,72	1,12	0,72	1,12	0,70	1,08
H_2O		0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	3,32	3,32
Total		100	100	100	100	100	100	100	100	100	100	100	100
Expenditure	mol/h	72,9		72,9		12,1		12,1		12,1		12,5	
	kg/h	1314,7		1314,7		218,5		218,5		218,5		226,0	
	st. m^3/h	1724,6		1724,6		286,6		286,6		286,6		296,5	
Relative molecular weight		18,02		18,02		18,02		18,02		18,02		18,03	
Density in st. con., kg/m^3		0,764		0,764		0,764		0,764		0,764		0,765	
Molar fraction of steam		1,00		1,00		1,00		1,00		1,00		1,00	
Volumetric expenditure mixture, m^3/h in wor.con.		138,3		143,7		25,9÷49,8		40,8		56,9		65,1÷32,8	
Mixture density kg/m^3 (in wor. con.)		9,51		9,15		8,43÷4,386		5,35		3,84		3,47÷6,89	
Mixture viscosity, cP (in wor. con.)		0,012		0,012		0,012÷0,02		0,017		0,020		0,020÷-	
Mixture enthalpy kcal/kg		-1055,2		-1055,2		-1054,9÷-880,3		-966,7		-880,2		-952,7÷-1141,7	
DNP on the raid, bar (37,8 °C)		-		-		-		-		-		-	

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Continuation of table 5

The name of indicators		Item number in figure 1											
		25		**26**		**27**		**28**		**29**		**30**	
Temperature, °C		194,7		194,6		194,6		112,8		193,1		39,7	
Pressure, bar		9,0		8,5		8,5		1,6		1,1		1,6	
Content of components, %		Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.	Moln.	Weight.
CH_4		88,97	79,18	88,97	79,18	0,15	0,14	0,15	0,14	88,97	79,18	0,28	0,20
C_2H_6		3,45	5,76	3,45	5,76	0,00	0,00	0,00	0,00	3,45	5,76	0,05	0,07
C_3H_8		1,21	2,96	1,21	2,96	0,00	0,00	0,00	0,00	1,21	2,96	0,06	0,11
iC_4H_{10}		0,25	0,81	0,25	0,81	0,00	0,00	0,00	0,00	0,25	0,81	0,03	0,07
nC_4H_{10}		0,26	0,84	0,26	0,84	0,00	0,00	0,00	0,00	0,26	0,84	0,04	0,10
$C_{5\text{-higher}}$		0,62	3,06	0,62	3,06	0,00	0,00	0,00	0,00	0,62	3,06	3,86	21,83
CO_2		1,22	2,98	1,22	2,98	0,07	0,18	0,07	0,18	1,22	2,98	0,02	0,03
H_2S		0,01	0,01	0,01	0,01	0,00	0,00	0,00	0,00	0,01	0,01	0,00	0,00
N_2		0,70	1,08	0,70	1,08	0,00	0,01	0,00	0,01	0,70	1,08	0,00	0,00
H_2O		3,32	3,32	3,32	3,32	99,76	99,67	99,76	99,67	3,32	3,32	95,67	77,58
Total		100	100	100	100	100	100	100	100	100	100	100	100
Expenditure	mol/h	12,5		12,5		0,0		0,0		12,5		1,1	
	kg/h	226,0		226,0		0,0		0,0		226,0		24,4	
	st. m^3/h	296,5		296,5		0,0		0,0		296,5		0,0	
Relative molecular weight		18,03		18,03		18,03		18,03		18,03		22,22	
Density in st. con., kg/m^3		0,765		0,765		1012,9		1012,9		0,765		962,247	
Molar fraction of steam		1,00		1,00		0,00		0,17		1,00		0,00	
Volumetric expenditure mixture, m^3/h in wor.con.		54,0		57,2		0,0		0,0		441,7		0,1	
Mixture density kg/m^3 (in wor. con.)		4,19		3,95		715,5		5,25		0,51		258,1	
Mixture viscosity, cP (in wor. con.)		0,016		0,016		0,080		-		0,016		-	
Mixture enthalpy kcal/kg		-1038,0		-1038,0		-3607,8		-3607,8		-1038,0		-3049,5	
DNP on the raid, bar (37,8 °C)		-		-		-		-		-		2,799	

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End of Table 5

The name of indicators		Item number in figure 1			
		31		32	
Temperature, °C		39,6		39,6	
Pressure, bar		1,1		1,1	
Content of components, %		Moln.	Weight.	Moln.	Weight.
CH_4		62,32	36,93	0,01	0,01
C_2H_6		9,54	10,60	0,01	0,01
C_3H_8		7,30	11,89	0,03	0,05
iC_4H_{10}		2,16	4,63	0,02	0,05
nC_4H_{10}		2,44	5,23	0,03	0,07
$C_{5\text{-higher}}$		6,54	21,35	3,85	21,83
CO_2		2,97	4,83	0,00	0,01
H_2S		0,01	0,01	0,00	0,00
N_2		0,20	0,21	0,00	0,00
H_2O		6,53	4,34	96,06	77,97
Total		100	100	100	100
Expenditure	mol/h	0,0		1,1	
	kg/h	0,1		24,3	
	st. m^3/h	0,1		0,0	
Relative molecular weight		27,08		22,19	
Density in st. con., kg/m^3		1,155		966,358	
Molar fraction of steam		1,00		0,00	
Volumetric expenditure mixture, m^3/h in wor.con.		0,1		0,0	
Mixture density kg/m^3 (in wor. con.)		1,15		911,3	
Mixture viscosity, cP (in wor. con.)		0,011		0,971	
Mixture enthalpy kcal/kg		-939,1		-3060,6	
DNP on the raid, bar (37,8 °C)		115,817		0,332	

C.3 Material balance of production

The material balance of production at the project facility is presented in Table 6.

table 6– Material balance of production

Name	Amount				
	m^3/h	kg/h	$10^6 m^3$/y	10^3 t/y	%
Income					
Raw gas	2083,3	1592,8	16,7	12,74	100,0
Output					
1 Dried and cleaned gas	1724,6	1314,8	13,80	10,518	82,55
2 Regeneration gas to torch	296,5	226,1	2,37	1,808	14,20
3 Fuel gas	36,2	27,6	0,290	0,221	1,73
4 Degassing gas	0,10	0,11	0,0008	0,001	0,007
5 Liquid (cond. + water)	0,026	24,2		0,194	1,519
Total	**2057,4**	**1592,8**	**16,46**	**12,74**	**100,0**

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II. CONCLUSION

The work was carried out on the basis of an assignment for the development of a working project "Installation of zeolite purification and dehydration of natural gas at a pilot production field".

Technological solutions have been developed for the design of the ZD&GPU with a basic technological scheme, the required number of adsorbers for drying and purification of gas has been determined, the technological parameters of the operation of the installation for drying and purification of gas with hourly costs have been determined.

As a result of the provided initial data and the implementation of material and heat balances in individual devices and in general, the following was obtained:

1.Basic technological solutions for design with a basic technological scheme were issued.

2.Determined the required number of adsorbers for drying and cleaning gas in volume $2{,}083\times10^3$ m^3/h ($16{,}6\times10^6$ m^3/y) with moisture content up to $3{,}7 g/m^3$(at the entrance to ZD&GPU).The block consists of three adsorbers, two of which are on adsorption, one on regeneration and on cooling.The duration of the adsorption cycle in the adsorber is 4 hours, regeneration – 4 h, cooling – 4 h. General cycle – 12 h.

3.The technological parameters of the gas drying unit operation with hourly consumption have been determined.Gas pressure at the unit inlet - 16 bar, temperature - 40 ° C.The regeneration gas volume supplied with 320°C temperature and 10.5 bar pressure and cooling supplied with 43.6°C temperature and 13 bar pressure is $2{,}29\times10^6$ m^3/y (286,7 m^3/h).

4.4. The implemented technological solutions will ensure the quality of gas required bySS 5542. [1]

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