Reduction of gas and aerosol pollution of atmospheric air at a condensate stabilization units

A V Ivanov¹, A V Strizhenok¹ and R Y Vorobey²
¹ Saint Petersburg Mining University, 2, 21st Line, St Petersburg, 199106, Russia
² Saint Petersburg State University, 7/9, Universitetskaya Emb., St Petersburg, 199034, Russia

E-mail: andrey-racer@mail.ru

Abstract. There is a wide variety of uses for non-compliant hydrocarbon products in addition to utilization by flaring, but the implementation of each of them is accompanied by a number of regulatory and technological restrictions. The paper analyzes the influence of the flare system on the state of the atmospheric air in the area of one of the gas condensate production facilities in Western Siberia. A detailed analysis of the composition of the combusted gas mixture is carried out, a review of existing methods of using non-compliant hydrocarbon gas raw materials is made. The technical substantiation of the possibility of introducing a gas turbine unit for power generation with the stage of intermediate gas accumulation in a soft gas tank of variable volume and also with a waste gas cleaning system to reduce the impact on the atmospheric air has been carried out. A detailed ecological and economic substantiation of the proposed measures is given.

1. Introduction
Liquid hydrocarbons produced at gas condensate fields are sent for processing to a condensate preparation plant for transportation. The enterprise separates light components - methane and ethane, after which the main product - deethanized condensate - is mixed with oil in a condensate pipeline and goes to the stabilization and processing plant (SPP) under consideration. This mixture contains raw materials of three different types: Valanginian (depth of 1 700 - 3 200 m), Achimov (depth of about 4 000 m) gas condensates and oil from oil rims (a thin layer of oil between a much larger gas cap and an aquifer) of gas condensate fields [1].

The distribution of base fractions in various types of raw materials is shown in figure 1.

In the condensates of the Valanginian and Achimov stages, the fraction with a boiling point of 140°C - 73% and 50%, respectively, prevails. Compared to the Valanginian condensate, the composition of the condensate of the Achimov deposits in the amount of 26% contains fractions with a boiling point of 240-340°C and above 340 ° C. For oil of oil rims, in turn, a high content of heavy fractions is characteristic, mainly with a boiling point above 340°C - 37% [2]. And unlike condensates of the Valanginian and Achimov stages, the oil does not contain C₁-C₂ hydrocarbon fractions.

The component-fractional composition of gas condensate supplied to the considered SPP is presented in table 1. A feature of the raw material resources of the SPP is an extremely low content of sulfur compounds in gas condensates (23-30 mg/kg).
Table 1. Component-fractional composition of the incoming oil-gas condensate mixture.

| Components | C_2 | C_3 | C_4 | H_2S | C_5-C_6 | Gasoline fraction | Diesel fraction | 340+°C |
|------------|-----|-----|-----|------|---------|-------------------|----------------|--------|
| mass %     | 0.53| 14.57| 18.59| -    | 13.56   | 40                | 10             | 3      |

The primary process of processing the oil and gas condensate mixture includes the stabilization of deethanized condensate, the production of stable condensate, a wide fraction of light hydrocarbons, liquefied hydrocarbon gas, waste gas; isopentane, propane, as well as the separation of isopentane, pentane-hexane and propane-butane fractions from a wide fraction of light hydrocarbons; separation of the propane-butane fraction into propane and butane by repeated rectification; utilization of bottom water with waste water treatment and methanol recovery, production of air separation products, nitrogen-oxygen station.

The secondary refining process includes the production of motor fuels; catalytic reforming, refining of motor fuels; utilization of low-pressure waste gases.

The flare facility is intended for burning emergency, periodic and permanent discharges of combustible gases from technological installations. The combustion of gases is carried out on two flare units of the UFMG-100HL.48 type, one of which is working, the other is backup (figure 2). Characteristics of the flare unit: nominal amount of gas flared 466 000 m³ per day, maximum amount of gas flared at a time 399 178 kg per hour, outlet nozzle diameter 2.8 m, density of the combusted mixture 2.07 kg per m³, unit operating hours per year – 8 760.

Figure 1. Content of basic fractions in various types of extracted raw materials.

Figure 2. Flare farm.

The composition of the combusted mixture is shown in table 2.

Table 2. The composition of the combustion mixture.

| Component name       | Volume % | Molar mass |
|----------------------|----------|------------|
| Methane (CH₄)        | 1.58     | 16         |
| Ethane (C₂H₆)        | 11.81    | 30         |
| Propane (C₃H₈)       | 55.77    | 44         |
| Bhutan (C₅H₁₀)       | 27.84    | 58         |
| Pentane (C₅H₁₂)      | 2.42     | 72         |
| Hexane (C₆H₁₄)       | 0.04     | 86         |
| Nitrogen (N₂)        | 0.35     | 28         |
| Oxygen (O₂)          | 0.17     | 32         |
| Carbon dioxide (CO₂) | 0.02     | 44         |

Total                | 100      | 46.4       |
Analysis of the data obtained shows that the combustion of substandard gases in a flare unit and the absence of a gas cleaning system at the enterprise have a negative effect on the state of atmospheric air in the nearby camp [3,4].

2. Materials and methods

The main pollutants and emissions are presented in Table 3.

| Pollutant code | Name of pollutant | Hazard Class | Maximum one-time emission of a pollutant (g per second) |
|----------------|------------------|--------------|------------------------------------------------------|
| 0301           | Nitrogen dioxide | 3            | 555.1373365                                          |
| 0304           | Nitrogen (II) oxide | 3          | 73.9598175                                           |
| 0328           | Soot             | 3            | 223.106538                                           |
| 0330           | Sulfur dioxide   | 3            | 3.5344783                                            |
| 0337           | Carbon oxide     | 4            | 3.792.811138                                          |
| 0402           | Butane           | 4            | 356.4628064                                          |
| 0403           | Hexane           | 4            | 870.1772297                                           |
| 0405           | Pentane          | 4            | 447.1386067                                          |
| 0410           | Methane          | -            | 2.708.5072515                                          |
| 0412           | Isobutane        | 4            | 194.0741226                                           |
| 1052           | Methanol         | 3            | 10.8537848                                            |
| 2754           | Saturated hydrocarbons C_{12}-C_{19} | 4            | 3.0692045                                             |

As can be seen from the tables, the main pollutants are hazard class 4 substances, which account for about 78% of the total gross emission and hazard class 3 substances, which account for about 18% of the total gross emission. Emissions of substances of the 1st and 2nd hazard classes are 0.01%, the main contribution is made by benzene, which belongs to the 2nd hazard class [5,6].

Technological processes that have the greatest negative impact on the atmospheric air:
- Combustion of non-compliant gases in a flare unit;
- Stabilization of condensate;
- Obtaining fuel fractions from stable condensate;
- Purification of gasoline and kerosene fractions from impurities, production of diesel fuel and high-octane component of motor gasolines.

As a result of the analysis of the obtained calculation of the maximum surface concentrations, the excess of the maximum allowable concentration at the border of the sanitary protection zone of the enterprise was revealed for the following substances: nitrogen dioxide, carbon (soot).

3. Results and discussion

There are various options for reducing emission volumes at the flare unit:

1. Minimization of gas flaring by means of its accumulation in a gas tank;

   The flare unit at the enterprise operates in a continuous mode and makes a significant contribution to air pollution with emissions of soot, methane, nitrogen oxides, carbon and sulfur. Flare gases, the main part of which is propane-butane fraction, can be collected in gas holders for further targeted use, for example, used as fuel or for purging technological devices, or can be sent to an existing waste gas recovery unit to extract commercial propane-butane.

2. Installation of a power plant to provide electricity to technological facilities of the enterprise [7,8];

   The installation of a power plant operating on a propane-butane mixture (which makes up 84% of the total volume of flared gas) will provide power to the plant’s technological facilities and thereby reduce power supply costs.

3. Modernization of the flare unit;
The emissions from the flare unit contain a large amount of soot, which indicates the underburning of hydrocarbon gases. The reason for the combustion with the release of soot is the discrepancy between the nozzle diameter and the actual combustion volume. After the commissioning of the waste gas utilization unit, the volumes of the flared gas decreased, which led to a decrease in the rate of gas outflow from the nozzle of the flare unit, while the high rate just provides the sootless combustion mode.

4. Use of waste gases as fuel in the boiler house [9];

On the territory of the main site of the Condensate Stabilization Plant, there is a boiler room, intended for uninterrupted process steam supply to the isopentane extraction unit and the propane production unit. The boiler room is equipped with six steam boilers. Since the structure of the combustion chamber depends on the type of fuel burned, then when using a different type of fuel, modernization will be required - the installation of special nozzles-jets of a different diameter, designed to work at a certain pressure. In general, equipment using conventional fuels is almost identical to equipment using alternative fuels.

5. Injection of gases into the reservoir to maintain reservoir pressure [10,11];

This event is characterized by high capital costs for the necessary technological equipment and the complexity of the application. In addition, the plant in question is not located at the field, which technically and economically complicates the implementation of such an event.

6. Implementation of a gas purification system for emissions.

Installation of gas cleaning equipment on a flare unit will significantly reduce both air pollution and reduce the payment for emissions of these pollutants. However, the use of only gas cleaning equipment is an irrational use of gas, due to its high energy value.

The implementation of each separately taken method has insufficient efficiency, therefore, at the enterprise under consideration, the following was proposed: to install a power plant to provide electricity to the enterprise's technological facilities with the purchase of a gas holder for temporary accumulation of flared gas and with the subsequent introduction of a gas cleaning system for emissions at the future installation [12].

The main sources of power supply to consumers of the energy district are GRES-1 and GRES-2 with an installed capacity of 20 825 400 kWh and 32 836 000 kWh [13,14].

The condensate stabilization plant is one of the main consumers of electricity and electrical capacity of the energy district. The balance of electricity at the enterprise for the previous year amounted to 294 000 000 kWh.

In terms of its qualitative composition, the flared gas belongs to pure hydrocarbon gas (the content of hydrocarbons is 99.46%). The proportion of impurities in the composition (nitrogen, carbon dioxide and oxygen) is 0.54%. An important point is the absence of hydrogen sulfide in the composition, which means that there is no need for additional gas purification from sulfur compounds. The net calorific value of the combusted mixture (the so-called "wet gas") is 22 825.33 kcal per m³.

Under normal conditions, a gaseous mixture, consisting mainly of a propane-butane fraction (84%), is in a gaseous state, and with a decrease in temperature or an increase in pressure it turns into a liquid state [15].

The most economical and modern option is a soft polymer gasholder of variable volume, which is characterized by resistance to corrosion, chemical, climatic effects and solar radiation, manufactured by hermetic welding of seams, and the gas is accumulated and stored at a pressure close to atmospheric (figure 4). These gasholders are characterized by a variable volume, high time-consuming (a device with a maximum volume of 250 m³ has a mass of about 550 kg), simplicity and quick installation, the possibility of using an unprepared site for placement, and low cost.

According to the Flare Systems Safety Guidelines, gas tanks must ensure that the required volume of waste gases is received within 5-10 minutes [16]. It is also necessary to carefully monitor the tightness of the equipment (the condition of the safety valves of the gas holders) so that an explosive mixture of gas and air does not form [17].

The device can be introduced according to the scheme (figure 4) with a three-way valve and a check valve. At the same time, in order to ensure the afterburning of emergency waste gases, the flare is not
taken out of service in accordance with the Flare Systems Safety Guidelines, but is equipped with an auto-ignition system.

![Figure 3. Soft gasholder.](image1)

![Figure 4. The scheme of collecting waste gases into the gas tank: 1 - three-way valve, 2 - check valve, 3 - gas tank.](image2)

In general, about 505,682.38 t per year of waste gas is produced at the technological units of the enterprise, of which ≈ 394,000 t per year is processed at the waste gas utilization unit, and the rest ≈ 111,682.38 t per year is burned at the flare unit. Accordingly, ≈ 305.98 t per day of waste gas is burned per day (147,816 m³ per day or 6,159 m³ per hour). Thus, you will need 2 flexible gas storage tanks manufactured by LLC NPF Polytechnika, with a volume of 5,000 m³ each.

As fuel for power generation, gas is usually used, which has undergone the processes of purification from impurities, compression to the required pressure, determined by the parameters of the gas turbine plant, drying and heating [18]. The gas requirements are regulated by the technical characteristics of the installations [19]. General requirements are described in Gas Turbine Units. Fuel Gas Requirements.

For gas, which contains more than 80% of heavy fractions, the possibility of its combustion at low pressure is considered in order to avoid detonation phenomena (explosion of the working mixture during compression). In this case, gas compression (the process of increasing the pressure using a compressor) is not required.

Each type of gas turbine plant has its own requirements for the quality of the fuel used and this factor is taken into account when building a gas turbine plant (according to individual projects for a specific customer). Gas coming from condensate stabilization units contains a small amount of undesirable impurities and water vapor [20], therefore, in this case, its preparation before the gas turbine units can be minimal.

The recommended power range of a gas turbine power plant (when used at the enterprise as the main source of electricity) is 12-25 MW and above. Since about 6,159 m³ per h of waste gas is usually burned in a flare unit per day, one of the possible options for installing a gas turbine power plant is the purchase of three gas turbine units GTU-6P manufactured by JSC Aviadvigatel with a capacity of 6.14 MW each, which can use waste gas as fuel. Main characteristics of the GTU-6P unit: electric power 6.14 MW, thermal power 11.44 Gcal per h, efficiency 27.2% (with a steam boiler 83%), fuel gas consumption 1853 m³ per hour, exhaust gas temperature, 474°C, exhaust gas flow rate 26.7 m³ per second, resource before overhaul 30,000 h, assigned resource 120,000 h.

In total, the gas turbine power plant will generate 161,359,000 kWh per year. Electricity. Fuel gas consumption per day will be 133,416 m³. Thus, the introduction of a gas turbine power plant will approximately halve the plant’s need for electricity supplies through its own power generation.

The share of energy generated at the gas turbine power plant from the total electricity generated by GRES-1 and GRES-2 will be: 161,359,000/(20,825,000 000+32,836,000 000)=0.3%.

The compressor is supplied with air, where it is compressed and sent under high pressure to the combustion chamber, where fuel (waste gas) is also supplied [21] (figure 5). In the chamber, fuel is mixed with air, the mixture is burned. Next, a stream of hot gas at a high speed enters the turbine blades, forcing it to rotate. The rotating shaft of the turbine drives a compressor and an electric generator. Since the exhaust gases have a high temperature, it is therefore rational to additionally equip the gas turbine units with a waste heat boiler to obtain heat energy [22]. The boiler is a container filled with water,
which the exhaust gases are heated, turning into steam, which is used for heating and heating [23]. The waste gas contains nitrogen oxides, carbon monoxide, carbon dioxide, hydrocarbons, sulfur oxides, soot particles, which requires the implementation of a gas cleaning system.

The choice of a method for cleaning gas turbine units emissions from pollutants is mainly influenced by the volume of emissions and their qualitative composition. Absorption in this case was chosen as the most versatile method for cleaning off gases. One of the most widespread absorption cleaning devices is the nozzle absorber (which is also proposed during the scientific work MK-130.2020.5). The advantages of this type of equipment are the simplicity of the device and low cost. It is also possible to use a packed absorber, where a large surface area of the contact between the phases - gas and liquid is achieved. The disadvantages of packed columns include: relatively low productivity, large volumes of packing and the apparatus itself.

At the designed gas turbine power plant, the volume of waste gases from each hour. Accordingly, it is necessary to install three units of the following type - absorber CH-100 of LLC PZGO. The main characteristics of the absorber SN-100: capacity 100 000 m³ per hour, purification degree 93-99%, hydraulic resistance no more than 1 kPa, gas flow rate 5-9 m/s.

Thus, the installation of a gas turbine power plant to provide electricity to technological facilities of the enterprise with the purchase of a gas holder for temporary accumulation of combustible gas and the subsequent introduction of a gas purification system at the future installation will significantly reduce pollutant emissions from flue gas combustion. It is assumed that the volume of combustible gas will decrease by about 95%, because it is not possible to completely abandon the flare installation. Some of
the gases will continue to enter the flare system for combustion during emergency emissions. The halos of pollutant dissipation constructed in the unified program of calculation of atmospheric pollution "ECOcenter" (used also in the course of work SP-3455.2019.3) for the flare installation before introduction and after introduction of the offered actions are given in figure 6.

Figure 6. Halo dispersal halos before (a) and after the implementation of the proposed measures (b) and nitrogen oxides before (c) and after the implementation of the proposed measures (d), built in the unified program for the calculation of air pollution "ECOcenter" for the flare. The numerical values in the figures are the ratios of concentration to the maximum allowable concentration.

An important aspect is the economic justification for the implementation of the proposed measures. Capital costs were calculated, as well as depreciation and material costs (table 4).

Table 4. The results of the calculation of capital costs, depreciation and material costs

| Name                   | Quantity | Gas turbine installation GTU-6P of JSC Aviadvigatel | Soft gasholder of LLC NPF Polytechnic | Absorber SN-100 LLC PZGO | Total |
|------------------------|----------|--------------------------------------------------------|--------------------------------------|--------------------------|-------|
|                        |          | 3                                                      | 2                                    | 3                        | x     |

7
The cost of one unit, USD 1 200 000 50 000 4 500 x  
Total cost of equipment, USD 3 600 000 100 000 13 500 3 713 500  
Transportation costs (10% of the cost of equipment), USD 360 000 10 000 1 350 371 350  
Installation costs (5-15% of the cost of equipment), USD 540 000 15 000 2 025 557 025  
Contingencies (5% of equipment cost), USD 180 000 5 000 675 185 675  
Capital costs, USD 4 680 000 130 000 17 550 4 827 550  
Depreciation deductions (annual depreciation rate with a service life of 10 years - 10% of capital costs), USD 468 000 13 000 1 755 482 755  
Material costs (raw materials, fuel, water, electricity), USD 0 (non-compliant gas is used) x 1 000 1 000

Next, the costs of ensuring the work of service personnel were calculated (table 5).

**Table 5.** The results of the calculation of the cost of ensuring the work of service personnel.

| Name                        | Operator | Technician | Total |
|-----------------------------|----------|------------|-------|
| Basic salary, USD           | 15 000   | 12 000     | x     |
| Number of staff             | 6        | 3          | 9     |
| Salary fund, USD            | 90 000   | 36 000     | 126 000 |
| Premium (15% of annual salary), USD | 13 500 | 5 400 | 18 900 |
| Salary fund with bonuses, USD | 103 500 | 41 400 | 144 900 |
| Social insurance (30% of the salary fund with bonuses), USD | 31 050 | 12 420 | 43 470 |
| Health and life insurance (0.5% of the salary fund with bonuses), USD | 86 | 69 | 155 |
| Amount of insurance premiums, USD | 5 261 | 4 209 | 9 470 |

The sum of capital and operating costs determines the total costs for the implementation of the proposed environmental measures (table 6).

**Table 6.** Calculation of total costs for the implementation of environmental measures.

| Name                        | Cost     |
|-----------------------------|----------|
| Capital costs, USD          | 4 827 550 |
| Depreciation, USD           | 482 755  |
| Material costs, USD         | 1 000    |
| Salary fund with bonuses, USD | 144 900 |
| Amount of insurance premiums, USD | 9 470 |
| Total costs for the implementation of environmental measures, USD | 5 465 675 |

Savings on payments for emissions of pollutants into the atmosphere were determined by the difference between payments before the implementation of the proposed measures and after their implementation (table 7).
Table 7. The results of the calculation of savings on payments for emissions of pollutants into the atmosphere.

| Name of the pollutant | Emission standard, USD per t | Extremely admissible emission, t per year | Emission before the event, t per year | Emission after the event, t per year | Fee for emissions (adjusted for inflation), USD per year before the implementation of measures | Savings, USD per year after the implementation of measures | Savings, USD per year |
|----------------------|-----------------------------|------------------------------------------|--------------------------------------|--------------------------------------|------------------------------------------------|------------------------------------------------|------------------------|
| Nitrogen dioxide     | 1.85                        | 1910                                     | 17 506.8 099                         | 875.3405                             | 1 749.56                                      | 189 109.9 3           |
| Nitric oxide         | 1.25                        | 452.85                                   | 2 332.39 69                          | 116.6198                             | 157.07                                      | 15 636.43            |
| Soot                 | 0.49                        | 756.6                                    | 7 035.88 66                          | 351.7943                             | 185.41                                      | 20 069.96            |
| Sulfur dioxide       | 0.61                        | 69.206                                   | 10.5321                              | 0.5266                               | 0.34                                        | 6.54                |
| Hydrogen sulfide     | 9.15                        | 0.969                                    | 0.0086                               | 0.0004                               | 0.01                                        | 0.08                |
| Carbon monoxide      | 0.02                        | 8 279.05 8                             | 119 610.0 877                        | 5 980.504 4                         | 137.79                                      | 15 443.36           |
| Methane              | 1.44                        | 2 728.87                                 | 2 991.26 53                          | 149.5633                             | 232.60                                      | 6 459.80            |
| Total                | x                           | x                                       | 149 486.987                          | 7 474.35                             | 1 749.56                                    | 189 109.9 3          |

The individual tariff for electricity transmission services between organizations according to the decision of the regional energy commission of the district is 0.0243444 USD per kWh. The balance of electricity at the enterprise for the previous year – 294 000 000 kWh. Since the projected gas turbine power plant is capable of generating 161 359 000 kWh per year. electricity, the savings on electricity payments will be 3 229 060.69 USD. The savings from the implementation of the measure will consist of savings on electricity bills and savings on emissions charges and will amount to 3 418 170.62 USD and the payback period will be less than two years.

4. Conclusion
Analysis of the obtained data shows that the combustion of substandard gases at the flare plant and the absence of a gas cleaning system at the enterprise have a negative impact on the state of the atmospheric air in the nearby shift settlement.

Technological processes that have the greatest negative impact on atmospheric air:

- Burning of substandard gases on a flare installation;
- Condensation stabilization;
- Obtaining fuel fractions from stable condensate;
- Purification of gasoline and kerosene fractions from impurities, production of diesel fuel and high-octane component of motor gasolines;

As a result of the analysis of the received calculation of the maximum surface concentrations, exceedances of the maximum concentration limit at the border of a sanitary protection zone of the enterprise on nitrogen dioxide and soot were revealed.
The implementation of each of the considered methods of reducing the negative impact is insufficient, so it was proposed to install a gas turbine power plant to provide electricity to technological facilities of the enterprise with the purchase of soft gasholders for temporary accumulation of combustible gas and subsequent introduction of absorbers for gas cleaning. The payback period of the proposed measures will be less than two years.

References
[1] Kasperovich A G and Borovkov A G 2016 Research and statistical analysis of the raw materials base of Gazprom Pererabotka in Western Siberia. Vesti gazovoy nauki 4(28)
[2] Bykova M V, Alekseenko A V, Pashkevich M A and Drenbenstedt C 2021 Thermal desorption treatment of petroleum hydrocarbon-contaminated soils of tundra, taiga, and forest steppe landscapes Environmental Geochemistry and Health DOI: 10.1007/s10653-020-00802-0
[3] Cheremisina O V and Al-Salim S Z 2017 Modern methods of analytical control of industrial gases. Journal of Mining Institute 228 726-30
[4] Alekseenko A V and Pashkevich M A 2016 Novorossiysk agglomeration landscapes and cement production: geochemical impact assessment. IOP Conference Series: Earth and Environmental Science. 43(1) article #2050
[5] Volkodava M V and Kiselev A V 2017 On development of system for environmental monitoring of atmospheric air quality. Journal of Mining Institute 227 589-96
[6] Volkodava M V and Taranina O A, Volodina Ya A, Kuznetsov V A 2019 Development of industrial environmental control methods. IOP Conference Series: Earth and Environmental Science 378(1), article #012108
[7] Shonin O B and Salov R A 2017 Improvement of energy efficiency, reliability and environmental safety of power plants based on associated petroleum gas. Journal of Ecological Engineering 18(3) 91-6
[8] Stroykov G, Cherepovitsyn A Y and Iamshchikova E A 2020 Powering multiple gas condensate wells in Russia’s arctic: Power supply systems based on renewable energy sources. Resources 9(11) 1-15
[9] Barkan M S and Kornev A V 2017 Prospects for the use of associated gas of oil development as energy product International Journal of Energy Economics and Policy 7(2) 374-383
[10] Turbakov M S and Kozhevnikov E V 2013 Utilization of associated petroleum gas at small fields. Neftyanoe khozyaystvo - Oil Industry 8 118-20
[11] Turyshcheva A V, Gulkov Y V and Krivenko A V 2020. Improving energy performance of the oil and gas industry by applying technologies for the use of associated petroleum gas. Topical Issues of Rational Use of Natural Resources 1 442-7
[12] Vasilenko N V 2017 Development of oil and gas service as organizational form of entrepreneurship in post-industrial economy. Journal of Mining Institute 227 597-602
[13] Government order of April 26, 2019 N 203-rp. On approval of the scheme and program for the development of the power industry of the Khanty-Mansi Autonomous Okrug–Yugra
[14] Razmanova S V and Andrukhova O V 2020 Oilfield service companies as part of economy digitalization: Assessment of the prospects for innovative development. Journal of Mining Institute 244(4) 482-92
[15] Tsvetkov P S and Fedoseev S V 2021 Analysis of project organization specifics in small-scale lng production. Journal of Mining Institute 246(1) 678-86
[16] Safety Guide for Flare Systems "Scientific and Technical Center for Research of Industrial Safety Problems" 2013 48
[17] Gasumov R A, Gasumov E R and Minchenko J S 2020 Features of the underground storages construction in depleted oil and gas condensate fields. Journal of Mining Institute 244(4) 418-27
[18] Turyshcheva A V and Baburin S V 2016 Justification of power supply system’s structure of oil and gas facilities using backup energy sources with associated petroleum gas as the energy carrier.
International Journal of Applied Engineering Research 11(1) 749-55

[19] Bakesheva A T, Irgibaev T I and Belousov A E 2019 Determination of natural gas loss values based on physical simulation of leakages from the pipeline to the media with superatmospheric pressure using a volumetric-type expander. News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences 3(435) 114-21

[20] Bondarev E A, Rozhin I I and Argunova K K 2018 Moisture content of natural gas in bottom hole zone. Journal of Mining Institute 233 492-7

[21] Drozdov A N and Gorbyleva Y A 2019 Improving the operation of pump-ejector systems at varying flow rates of associated petroleum gas. Journal of Mining Institute 238 415-22

[22] Leusheva E L, Morenov V A and Martel A S 2019 Combined cooling heat and power supplying scheme for oil and gas fields development. Youth Technical Sessions Proceedings- Proceedings of the 6th Youth Forum of the World Petroleum Council- Future Leaders Forum 382-6

[23] Leusheva E L and Morenov V A 2017 Development of combined heat and power system with binary cycle for oil and gas enterprises power supply. Neftyanoe Khozyaystvo - Oil Industry 7 104-6