Determination of the gas factor of oil at Western Siberia fields

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Abstract. The article presents the results of applying the method for determining gas factors at the wellhead of the support network of wells and separation sites of LUKOIL-Western Siberia LLC. The object is systems of oil separation and treatment, collection and transportation of gas from fields developed by LUKOIL-Western Siberia LLC. The aim is to measure the amount of gas produced together with oil, and specify gas factors by fields. The article describes and analyzes the existing oil treatment systems and gas collection and transportation systems. The tie-in points for field measurements of gas consumption have been determined. Instrumental field measurements of gas consumption in pipelines at all separation facilities and laboratory studies of properties and composition of gas were conducted. The relevance of the research is due to the increasing attention to the rational use, reduction of losses and an increase in the overall level of use of gas extracted from the subsoil.

1. Introduction

To determine the flow rate of gas delivered to consumers and the flow rate of gas sent to the flare, tie-ins were made for special technical means based on the use of Pitot pressure pipes. Gas consumption for own needs (PTB furnaces, boiler rooms, etc.) was determined using equipment, passport data of gas consuming devices and their actual state for the survey period.

The field gas factor for the gathering unit (BPS) was calculated as the ratio of the total gas flow rate, plus the residual gas content in oil to the volume of oil production for the period under consideration [1].

The choice of tie-in points for measuring instruments was made taking into account technological schemes of each booster pump station and composition of the technological equipment of oil field facilities [8].

The territorial production enterprise Kogalymneftegaz is part of LUKOIL-Western Siberia. Kogalymneftegaz extracts oil at the following fields: Povkhovskoe, Vatyeganskoe, South-Vyintoskoe, South-Yagunskoe, Ravenskoe, Druzhnoe, Kustovoe, East-Pridorozhnoe, Tevlin-Russkinskoe, North-Kochevskoe, North-Konitlorskoe. In addition, oil production operators are CJSC Eganoil, which produces oil at the Gribnoe field, and NGDU Ritekneft, which operates at the Tevlin-Russkinskoe and Ikilorskoe fields.

2. Materials and methods

The research methods are field and laboratory measurements at oil separation and treatment sites located in the area of Kogalymnneftegaz operation.

The volume of gas supplied from the first stages of oil separation of oil gathering points at the GPP and the volume of gas flared and used for own needs were determined, the gas factor of oil was determined by separation sites and fields in general [5].

The analysis provided for the selection and analysis of the composition of the associated gas, the determination of its main physical and chemical characteristics. To determine the residual gas content...
in oil, oil samples were taken at each treatment facility [7].

The gas flow rate is determined by means of low-pressure Pitot pipes introduced into the gas flow through specially equipped holes. The secondary device is either a differential pressure gauge (at a pressure of more than 0.2 atm.), or a multi-range micromanometer MMN-240 with an inclined tube and accuracy class 1.0 [2]

3. Results and Discussion

All fields of Kogalymneftegaz are equipped with a pressurized sealed collection system.

The gas-liquid mixture from the group metering units under wellhead pressure enters the nodes of the first separation stage located at the booster pump station sites consisting of gas pre-sampling devices (UPOG) and oil and gas separators, where the first stage of separation is carried out at a pressure that provides compressorless gas transport to COP. The partially degassed gas-liquid mixture enters the second stage separators, where the second stage of separation is carried out [10].

As separators of the first, second and end separation stages, NGS separators are used [3].

At most sites, gas is purified in remote gas separators. An apparatus with a volume of 4, 8, 12, 25, 50, 100 m3, or NGS separators without re-equipment are used.

To unload the first stage oil and gas separators, some BPS are equipped with gas pre-selection devices (GPD).

With the booster pump station, the pre-separated and partially dehydrated liquid is pumped out to the central heating station, where it undergoes a full cycle of preparation at the OTP by the method of thermochemical dehydration using pipe-type PTB-10 heaters, pressure settling tanks, electric dehydrators and commercial tanks. Then it is delivered to the system of main oil pipelines through the commercial accounting unit [11].

Oil preparation is carried out at five CPFs: CPF of the Vatyeganskoe field, CPF of the Povkhovskoe field, CPF of the South-Yagunskoe field, CPF of the Druzhnoye field, CPF of the Tevlin-Russkinskoe field.

Gas of the first stages of the booster pump station is transported to the consumer (Povkhovskaya compressor station, Kogalym compressor station, GPP, SDPS); gas of the second stages is burned in flares or taken by a vacuum compressor station (VKS).

Works were also performed at the Tevlin-Russkinskoye field along the booster pump station-3, booster pump station-5, booster pump station-7, 7 and the central heating station. The tie-ins are made in pressure gas pipelines and high and low pressure flare lines. At the central heating station, five tie-ins were made in the gas supply lines from the KSU. Oil from the North-Kochevskoe, North-Konitlorskoe, Kochevskoe, and East-Perevalnoe fields is prepared at the CPF of the Tevlin-Russkinskoe field [6].

According to GOST 17.2.4.06-90, the measuring section was selected on a straight section of the gas pipeline at a sufficient distance from the places where the gas flow direction (elbows, bends) or the cross-sectional area of the gas pipeline (valves, throttling devices, etc.) changes [4]. The minimum length of the straight section should be 4-5 equivalent diameters [6].

Pressure pneumometric Pitot tubes manufactured by AP EPM GGO n.a. A.I. Voeikov, St. Petersburg are used for measuring the gas factor. The Pitot tube (full head tube) is designed to measure the volumetric flow rate of liquid and gas at one point in the cross section of cylindrical pipes. It is used to determine the speed and volumetric flow rate in gas ducts and ventilation systems using a digital differential DMC-01 pressure gauge or a MMN-240 micromanometer [9].

The differential digital pressure gauge is a professional device designed to measure differential pressure, process control of gas and dust flows, control ventilation of industrial premises, environmental control of emissions, aerodynamic research, etc. With high-speed pressure tubes NIIOGAZ or PITO, the DMC-01M can determine speed and flow rates of gas flows in pipelines.

The built-in microprocessor is used to measure and accumulate data on gas duct sections (the velocity profile at N <99 points), calculate local velocities and gas flow rates corrected for the flow temperature, average gas velocities and flow rates by measured points.
All information about the device is displayed on a large display equipped with backlight. After each measurement, the indicator shows the following readings: the value of a dynamic head in mm w.c. or Pa; the local speed at a given point of measurement in m/s; the average speed in m/s for N measurements; the average value of gas consumption in m³/h.

At the booster pump station-5 of the Tevlin-Russkinskoe field, gas of the first stage of separation is used for own needs and sent to the compressor station, the gas of the second stage is fed to the flare. The GOR was calculated taking into account part of the oil coming from the booster pump station-7 of the Tevlin-Russkinskoe field.

At BPS-7, all the high-pressure separation gas is sent to the compressor station, and the second-stage separation gas is fed to the flare. When calculating the gas factor of BPS-7, the amount of gas and oil supplied from MNFS-1 and MNFS-2 of the North-Kochevskoe field was taken into account.

At the central heating station, gas is measured at five points at the outlet of the separators. When measuring gas flow rates, gas samples were taken for laboratory analysis.

Gas sampling was carried out with a device consisting of a rubber tube, a container with a capacity of 500 ml, and a vessel with water. A clean container was filled with a special saturated saline solution and lowered into a vessel with salt water. Then the free end of the rubber tube (the other end is connected to the pitot pressure tube) was put into the container under water. Pressurized gas forces the solution out of the container. The container was closed, thus ensuring the absence of contacts with the atmosphere.

A gas sample was taken at each measurement of the gas flow at the point of measurement from pressure gas pipelines and flare lines.

The composition was determined using the Tsvet-800 gas analytical chromatograph by the chromatographic methods.

The volume of non-hydrocarbon components (carbon dioxide, nitrogen, oxygen), as well as light hydrocarbons methane and ethane was determined using a molecular column with a thermal conductivity detector according to GOST 23781-87.

The analysis mode was controlled and results were processed by a personal computer using the Tsvet-Analytic software, which collects and processes chromatographic data: analog-to-digital conversion, noise filtering, integration, qualitative and quantitative analysis of the components [12].

Gas under the separation pressure is transported from the separation units of the booster pump station to the gas processing plant. The gas flow rate was measured using the "heavy" Pitot tube, which was installed on a valve cut into the gas pipeline with a full bore of 100 mm in diameter. A differential pressure gauge DT-50 with a division value of 1 mm was used as a secondary device showing the pressure difference between the static and dynamic heads. The results of determination of gas factors are shown in Table 1.

The values of gas factors for the fields of Kogalymneftegaz, corrected taking into account the available results of studies of depth samples, approved by Kogalymneftegaz and recommended for approval by the UTO Gosgortekhnadzor are presented in the Appendix.
Table 1. Results of gas factor determination

| Deposit                     | Gas factor, m³/t |
|-----------------------------|-----------------|
| Vatyeganskoe                | 47              |
| Povkhovskoie                | 79              |
| Yuzhno-Vyintoysoke          | 98              |
| Yuzhno-Yagunskoie (East Dome)| 49              |
| Tevlin-Russkinskoie         | 49              |
| Druzhnoe                    | 59              |
| Gribnoe                     | 97              |
| East-Pridorozhnsoe          | 76              |
| Kochevskoie                 | 63              |
| Ravenskoie                  | 76              |
| North-Kochevskoie           | 68              |
| Kustovoe                    | 57              |
| North-Konitlorskoie         | 79              |

4. Conclusion

The need to determine gas factors at the fields of oil producing companies is due to the increasing attention to the problems of environmental control over emissions into the atmosphere, the need to control the development of fields, detect and eliminate undesirable phenomena such as gas breakthrough in gas caps, in-situ degassing, the level of gas utilization, reducing the amount of technological and other losses.

The following works have been performed:
- field measurements of associated gas consumption were performed;
- samples were taken, a chromatographic analysis was carried out, and physical and chemical properties of associated gas were determined;
- The gas factors were determined based on the measurements of gas consumption at separation sites, laboratory studies of gas properties and data on oil production provided by the customer.

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