Features of the low-pressure APG treatment and compression process procedures

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The importance of the quality of associated petroleum gas treatment and compression for its subsequent recovery implies specific requirements for the reliability and efficiency of the process equipment used in this segment of the oil and gas industry. Experts of the ENERGAS Group have developed a quite complete understanding of the problems caused by the specifics of operation with APG, and suggest a number of solutions based on their professional experience.

Associated petroleum gas (hereinafter – APG) means natural hydrocarbon gas dissolved in oil or located in the «gas-caps» of oil and gas condensate fields. With the development of the infrastructure necessary for its rational use, the need for its burning is reduced.

The consistent increase in the share of effective APG recovery opens up prospects for the growth economic and ecological efficiency of the oil and gas sector, and this, on its turn, puts forward new challenges for the gas treatment equipment designers and manufacturers.

Further improvement of the process equipment, which is used for APG gathering, treatment and processing, expands the possibilities of using APG in various industries and for the auxiliaries of the oil and gas fields, such as power generation (photo 1).

Photo 1. The northernmost GTPP – East-Messoyakhskaya – operates on a low-pressure associated petroleum gas

CRITICAL FEATURES OF APG OPERATION

Let us list some features of APG operation, which have a critical impact on the equipment design and technological solutions.

Changes in the composition of APG depending on the period and/or gas production specifics

Associated petroleum gas supplied for further treatment has the property of chemical compositionchanges over time. This happens due to the following factors:

- At the stage of the well development and obtaining of primary gas samples, which are used as the basis for the process equipment design, the composition of APG may differ from the actual gas composition at the time the equipment starts operating;
- Gas composition may change over time due to depletion of deposits;
- Gas can be supplied to gas treatment units from several sources (photo 2), and the actual composition of gas will depend on the proportions of the gas mixture of different origins.

High APG dew point temperature

Starting from the second and subsequent stages of oil separation, the content of heavy C_{3+} hydrocarbons in the produced gas increases in comparison with APG of the first separation stage.

This feature of gas leads to a significant growth of the dew point temperature.

Considering the possibility of gas composition changes over time, this factor becomes valuable when designing gas treatment units, since the condensate formation volume increases the risk of emergency shutdowns of equipment and its failure.

In addition to heavy hydrocarbons, APG can contain a significant amount of water, condensation of which is also possible during gas treatment.

Low gas pressure at the inlet of the gas treatment equipment

- The low pressure of the working medium at the inlet of the compressor unit (photo 3) refers to the factors complicating the design, as it entails the following difficulties:
- Due to the fact that a vacuum can often occur at the inlet of the unit, a reverse flow of gas into the inlet pipeline, which is often accompanied by oil carryover, occurs at each equipment shutdown;
- When the gas pressure at the inlet of the compressor unit is below atmospheric, there is a probability of atmospheric air penetration into the gas piping through the leakiness, and it significantly increases the overall risk of the gas treatment process.

Chemicals in gas

Practice shows that associated petroleum gas often contains chemical compounds of different origin, not recorded in the characteristics of gas, based on which the equipment is designed.

This feature may not appear itself in the process of equipment operation. However, under certain conditions, prerequisites may arise for such compounds to drop into the oil system of a compressor unit. This leads to the deposition of sediments in the oil system (a typical example is the clogging of oil filters in the absence of mechanical pollutants).

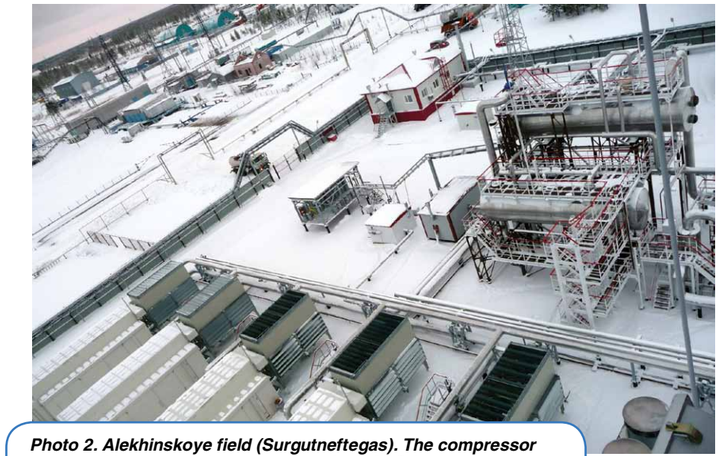

Photo 2. Alekhinskoye field (Surgutneftegas). The compressor station of low separation stages receives APG from several sources

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Photo3. BPS-3 of North-Labatyugan field. Compressor units pump the associated gas with negative inlet pressure values (from -0.02 MPa g.)

Severe climatic conditions in locations of equipment placement

Most of the facilities that use APG are located in the northern part of the Russian Federation, including the Arctic Circle (photo 4). In conditions of extremely low ambient temperatures during the winter, and a short but hot summer, the following situations that potentially affect the reliability of the equipment may arise:

- Freezing of thin pipelines of the condensate drainage system;
- Freezing of thin oil system piping;
- Increased temperature in the process compartment of the compressor unit in the summer months.

Note that factors such as a wide range of gas composition and its variability, high dew point and the presence of moisture in gas require the following special measures:

- Installation of the inlet filter scrubber with sufficient reserve for filtering and separating characteristics (Fig. 1);
- Installation of a condensate drainage system from the inlet scrubber using vacuum pumps or high-pressure gas from the discharge of a compressor unit for efficient removal of condensate at a low gas pressure at the entrance to the unit;
- Use of a slug catcher if peak liquid volleys from a piping system and upstream process equipment are possible.

Design calculation of the process procedure inside the compressor unit

The predominant content of heavy hydrocarbons significantly increases the dew point temperature of associated petroleum gas. Therefore, to ensure reliable uninterrupted operation of equipment, process procedures are designed so that the temperature of the medium is above the dew point of water and hydrocarbons at each point, and conditions for condensation are excluded. When designing the equipment, we also take into account that the compressible gas composition may change over time under the influence of various factors. Thus, the primary protection of the internal components of the equipment from failure is achieved.

At the same time, after completion of the compression process to further gas treatment for its transportation or supply to the end user, gas is cooled in shell-and-tube heat exchangers with an integrated condensate collector, which lowers the APG dew point. In some cases, a scheme with a recuperative heat exchanger is used, in which gas after the separation of condensate is heated by the heat obtained during compression. As a result, at the compressor unit outlet we obtain gas with a temperature substantially higher than the dew point temperature, and, accordingly, when gas is cooled during transportation, no condensation occurs.

SOLUTIONS

Many years of experience in the supply of APG treatment process equipment have served us well in developing a set of measures to eliminate the negative impact of a number of APG features. Let us highlight the main directions.

Individual equipment design

The process of gas compression directly depends on the quality of the compressed medium, which, in particular, implies the absence of mechanical impurities and condensate. Hence, special attention is paid to preliminary treatment of APG.

Photo 4. Oil treatment plant at Varandey field (LUKOIL-Komi). ENERGAS low pressure compressor station operates reliably in the Arctic conditions

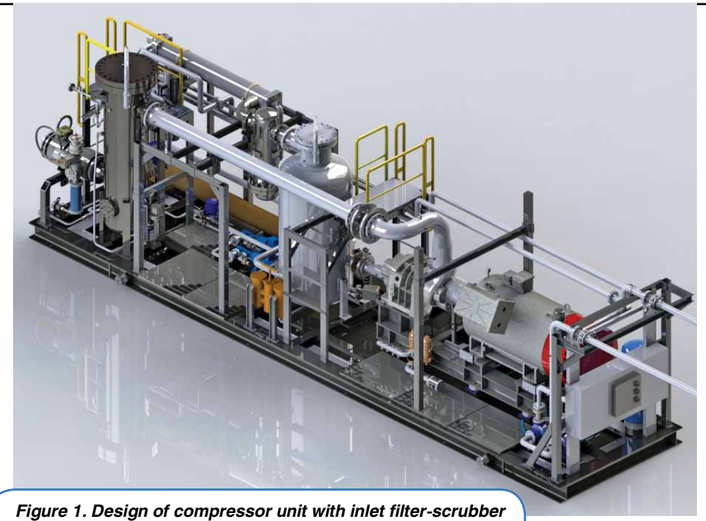

Figure 1. Design of compressor unit with inlet filter-scrubber (units are in operation as a part of South-Nyurymskoye field GTPP)

Use of specialized oils in the oil system of units

As an additional method of protection, our specialists have chosen using specialized ester based oil of the ESTSYN brand in the oil system of compressor units. This oil was developed in cooperation with a group of technical and service specialists from the manufacturers of compressor units. Analysis of data on the operation of the oil obtained during trial operation at compressor units with APG confirms the following:

- Oil does not foam even under conditions of high cyclical circulation in the oil system (up to 4 cycles per minute);
- Resistant to saturation with heavy hydrocarbons;
- Reduces corrosiveness of hydrocarbon gases;
- It has increased resistance to any aggressive impurities;
- Excludes varnish and sludge formation in the oil system and in the compressor unit;
- Keeps the operational properties during the long period of use;
- Adapted for use in any climatic conditions, including extreme ones;
- Effective when compressing gas of various types and composition;
- Helps maintain performance characteristics and the condition of screw compressors without significant changes during the established operational period between scheduled maintenance.

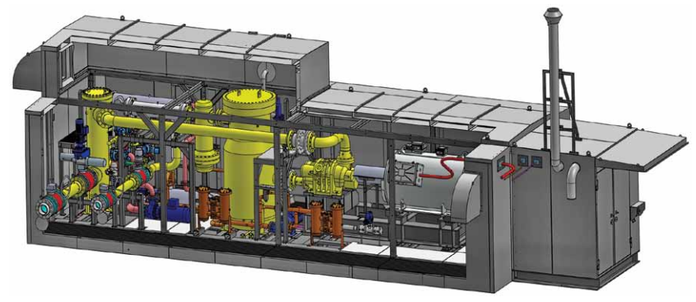

Figure 2. Model of the gas compressor unit with Arctic execution individual enclosure for GTU-CHPP of Usinsk field

Thus, the use of special lubricants with careful calculation of all process procedures occurring in the unit eliminates the risk of equipment failure for reasons related to the composition of gas.

Selection of unit's components and design of systems for their own needs

In order to ensure the efficiency of APG treatment units in conditions of extremely low ambient air temperatures, we take the following measures:

- All process equipment and elements of the control system are located inside the individual shelter (Fig. 2);
- The shelter is equipped with a heating system based on electric heaters with forced convection of air inside the shelter;
- The oil tank of the compressor unit is equipped with a submersible oil heater;
- The most critical points of the unit process flow diagram, such as condensate drainage pipelines, if necessary, are equipped with heating systems based on heating cables.

In addition, to ensure compressor units reliable operation during the winter period, this equipment serves to ensure quick start-up of equipment after long periods of inactivity without the use of additional pre-heating.

During the summertime, when the ambient air temperature even in the northernmost points of the country is very high, the ventilation system ensures the removal of excess heat from the process compartment of the compressor unit. The heat removed from the oil and gas coolers is discharged into the environment using the air cooler (photo 6), designed to work in such conditions.

Due to the lack of the possibility to use a compressible medium or compressed air as the working medium for the drives of the compressor units' mechanisms, we use electrically-driven valves. Fail-safe high-speed motor-operated valves are used at especially important positions of the process diagram, which allows to switch off the unit at the gas inlet and outlet in case of an emergency shutdown.

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ENERGAS compressor units, operating with a LP APG with inlet pressure below 0.4 MPa g

Region	Field	Facility	Number of units	Purpose of units	Inlet pressure of APG, MPa (g)
Khanty-Mansi Autonomous Area	North-Labatyugan	BPS No.3	2	gas transportation	-0.02
Republic of Sakha (Yakutia)	Talakan	CPF	1	gas transportation	-0.02
Republic of Sakha (Yakutia)	Talakan	BPS No.2	1	gas transportation	-0.02
Khanty-Mansi Autonomous Area	Alehinskoye	CPF	4	gas transportation	0
Khanty-Mansi Autonomous Area	Fedorovskoye	OPPS	2	gas transportation	0
Khanty-Mansi Autonomous Area	West-Surgut	OVD	2	gas transportation	0
Khanty-Mansi Autonomous Area	Lyantor	OPPS	2	gas transportation	0
Nenets Autonomous Area	Varandey	OTP	3	gas transportation	0
Khanty-Mansi Autonomous Area	Surgut city	TAP	1	gas transportation	0
Yamal-Nenets Autonomous Area	Vyngapur	CPF (BPS No.3 area)	2	gas transportation	0.001
Yamal-Nenets Autonomous Area	Vyngapur	BPS No.1	1	gas transportation	0.001
Khanty-Mansi Autonomous Area	Sovietskoye	FWKO No.3	1	gas transportation	0.001
Khanty-Mansi Autonomous Area	Sovietskoye	FWKO No.9	1	gas transportation	0.001
Yamal-Nenets Autonomous Area	Ety-Pur	BPS No.2	1	gas transportation	0.001
Yamal-Nenets Autonomous Area	Vyngayakha	OPPS	1	gas transportation	0.001
Khanty-Mansi Autonomous Area	Vakhskoye	FWKO No.4	1	gas transportation	0.001
Khanty-Mansi Autonomous Area	Vakhskoye	FWKO No.5	1	gas transportation	0.001
Yamal-Nenets Autonomous Area	Vyngapur	FWKO (BPS-2 area)	1	gas transportation	0,001
Khanty-Mansi Autonomous Area	Rogozhnikovskoye	CGTP (CPF area)	1	gas transportation	0.02
Khanty-Mansi Autonomous Area	Konitlor	BPS No.1	2	gas transportation	0.1
Khanty-Mansi Autonomous Area	Konitlor	BPS No.2	3	gas transportation	0.1
Khanty-Mansi Autonomous Area	Fedorovskoye	OPPS	2	gas transportation	0.1
Republic of Belarus	Rechitsa	CS	2	gas transportation	0.1
Yamal-Nenets Autonomous Area	Bolshekhetskaya Depression	TSLH	1	gas transportation	0.1
Khanty-Mansi Autonomous Area	Bystrinskoye	FWKO No.2	2	gas transportation	0.15
Khanty-Mansi Autonomous Area	Vatyegan	GTTP (72 MW)	4	gas supply to turbines	0.15
Tomsk Region	Igolsko-Talovoye	GTTP (12 MW)	2	gas supply to turbines	0.17
Khanty-Mansi Autonomous Area	North-Labatyugan	GTTP (36 MW)	6	gas supply to turbines	0.2
Khanty-Mansi Autonomous Area	Rogozhnikovskoye	GTTP No.1	1	gas supply to turbines	0.2
Khanty-Mansi Autonomous Area	Ai-Pim	BPS	4	gas transportation	0.2
Yamal-Nenets Autonomous Area	East-Messoyakha	GTTP (84 MW)	4	gas supply to turbines	0.2
Khanty-Mansi Autonomous Area	South-Vatlor	BPS	2	gas transportation	0,2
Tyumen Region	South-Nyurymskoye	GTTP (8 MW)	2	gas supply to turbines	0.2
Khanty-Mansi Autonomous Area	Ulyanovskoye	CS	2	gas transportation	0.25
Khanty-Mansi Autonomous Area	West-Mogutlor	MTPS	1	gas transportation	0.25
Khanty-Mansi Autonomous Area	West-Chigorinskoye	GTTP (12 MW)	3	gas supply to turbines	0.3
Yamal-Nenets Autonomous Area	Verhne-Nadymskoye	GTTP (24 MW)	3	gas supply to turbines	0.3
Khanty-Mansi Autonomous Area	Rogozhnikovskoye	GTTP No.2	3	gas supply to turbines	0.3
Khanty-Mansi Autonomous Area	Bittemskoye	CS	3	gas transportation	0.3
Khanty-Mansi Autonomous Area	Muryaun	CS	3	gas transportation	0.3
Khanty-Mansi Autonomous Area	East-Perevalnoye	GTTP (28 MW)	1	gas supply to turbines	0,3
Nenets Autonomous Area	South-Khylchuyu	GTTP (125 MW)	4	gas supply to turbines	0.35
Khanty-Mansi Autonomous Area	Tevlinsko-Russkinskoye	GTTP (48 MW)	3	gas supply to turbines	0.35
Yamal-Nenets Autonomous Area	Pyakyakha	OTP and TSU	1	gas transportation	0.39
Khanty-Mansi Autonomous Area	Konitlor	GTTP (24 MW)	3	gas supply to turbines	0.4
Khanty-Mansi Autonomous Area	West-Kamynskoye	GTTP (24 MW)	3	gas supply to turbines	0.4
Khanty-Mansi Autonomous Area	Muryaun	GTTP (24 MW)	3	gas supply to turbines	0.4
Khanty-Mansi Autonomous Area	Yukyaun	GTTP (36 MW)	3	gas supply to turbines	0.4
Khanty-Mansi Autonomous Area	North-Labatyugan	GTTP (24 MW)	3	gas supply to turbines	0.4
Khanty-Mansi Autonomous Area	Tromyegan	GTTP (12 MW)	3	gas supply to turbines	0.4
Republic of Sakha (Yakutia)	Talakan	GTTP (144 MW)	6	gas supply to turbines	0.4
Khanty-Mansi Autonomous Area	Rogozhnikovskoye	GTTP No.1	3	gas supply to turbines	0.4
Novosibirsk Region	Verh-Tarskoye	GTTP (10.4 MW)	2	gas supply to turbines	0.4

Photo 5. ENERGAS vacuum compressor stations for CPF BPS-3 of Vyngapur field (Gazpromneft-NNG) have a design specialized for LP APG with 0.001 MPa inlet pressure

It prevents oil entrainment to the inlet pipeline. This technical solution allows you to avoid the irretrievable loss of oil and save the filter elements of the inlet filter scrubber.

To ensure the safety of the process, we use specialized systems to control the oxygen content in compressible gas. This allows the control system to react to the ingress of air into the compressible medium and to stop operation before any consequences occur.

Photo 6. Air coolers for compressor units

CONCLUSION

At present, 122 of our compressor units (see table) are used in operation with low-pressure associated gas (inlet pressure range -0.02 ... 0.4 MPa g). Among them, 57 units operate at gas gathering and transportation facilities, and 65 treat LP APG as fuel for autonomous power supply complexes of the fields.

Based on the experience gained by the ENERGAS Group in the harshest operating conditions of gas treatment and compression units, our team has created a comprehensive system of knowledge, engineering and managerial skills to find and implement effective solutions taking into account facilities geography, type of working medium and process procedures features.

Each gas treatment project performed by us is individual. With the lowest possible cost, the optimum efficiency potential and maximum reliability are achieved in our projects.

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