COMPLEX USE OF GAS PRODUCTION FACILITIES IN THE CONDITIONS OF DEVELOPMENT OF THE URENGOY FIELD

Alexander Jur'evich Koriakin
Limited Liability Company ‘Gazprom dobycha Urengoy’,
Novy Urengoy, Russian Federation

ABSTRACT

One of the problems of the exploitation of Cenoman and Valanginian complexes is release of the capacity of machines for gas processing and compression. Herewith it is needed to input the processing plants for hydrocarbon extraction from the deposits of Achimovsk stratum. The aim of this work’s research is to develop technical decisions for optimization of existing machines work load and reduction of expenditures for implementation of new objects of deposits development. The article informs about the technical decisions for increase of work load of existing machines, developed in ‘Gazprom Dobycha Urengoy’ LLC and based on the analytical calculations and technological modeling of gas processing and compression processes.

Keywords: Central gas processing facility, Gas compressor unit, Work load of technological equipment, Common exploitation of the deposits, Achimovsk stratum deposits, Preliminary gas processing terminal.


1. INTRODUCTION

The area of the Urengoy oil, gas and condensate field, one of the largest land fields in the world, is over 5 thousand square kilometers. Profile of the Great Urengoy deposits includes three layers of gas content (Figure 1) [1, 2]. The upper gas content layer is the Cenomanian gas deposits that lay at the depth of 1030-1280 meters. Mid layer – Lower Cretaceous oil, gas and condensate deposits that form separate fields: Urengoy, Yen-Yakhin, North Urengoy and Pestsovoye. The deposits of these fields belong to the Valanginian type that include up to 17 gas beds at the depth from 1700 to 3340 meters. The lower gas content layer is oil, gas and condensate deposits of the Achimov horizon at the depth of 3550 to 4000 meters. The Cenomanian, Valanginian and Achimov deposits have been developed since 1978, 1985 and 2008, respectively.
The uniqueness of geological structure and reserves of the Urengoy field made it necessary to search for new approaches to the development, construction and exploitation of deposits.

A group decentralized collection scheme was used during the development[3, 4, 5]. Its peculiarity is the processing of hydrocarbon raw material by several high-capacity gas processing plants (GPP) and supply of the product from them to the gas transportation system through the interfield pipeline.

16 GPP’s are used to extract gas from the Cenomanian deposits, 5 – to extract gas from the Valanginian deposits, 2 central collection points (CCP) for oil extraction and 2 for gas extraction from the Achimov deposits. The prepared gas is collected into the interfield pipeline, which connects the GPP’s and CCP’s with the main compressor stations. The condensate is transported via the pipeline system to the Condensate Pre-Transportation Preparation Plant of Gazprom Pererabotka LLC, and the oil is delivered to the Urengoy-Surgut condensate pipe.

At the Great Urengoy field, Diethylene glycol dehydration process was used for the preparation of the Cenomanian gas and the low temperature separation (LTS) process for the preparation of the Valanginian gas. Booster compressor stations (BCS) were introduced at the Cenomanian GPP’s in order to maintain the required outlet pressure of the gas processing plants. They consist of two compression facilities with gas compressor units (GCU’s) of 16 MW of typical power rating. Custom booster compressor stations were also installed at the four of the Valanginian GPP’s with gas compressor units of 10 MW of typical power rating; it is planned to install another booster compressor station at the GPP-11V.

Any oil and gas field has its periods of an increasing output, stabilization of production and then a decrease as hydrocarbon reserves dwindle and formation pressure reduces [6, 7]. Each of these periods requires solving specific tasks of field exploitation. During periods of increasing output and stabilization, it is necessary to place into operation the equipment for gas extraction, preparation and compression. Whereas a decrease in the output leads to worse
conditions of equipment maintenance and requires improvement of technological processes of
gas extraction and preparation as well as disposal of equipment.

The maximum level of Cenomanian gas extraction was reached in 1987 [5, 8]. In
comparison with the peak level, gas extraction has decreased approximately five times by the
present time. This led to a reduction in the capacity utilization of the facilities for gas
purification, dehydration and compression; excess capacity of process equipment today is about
80%. Production lines are decommissioned in order to ensure the required utilization of gas
separators and dehydration facilities. It is impossible to implement this approach at the booster
compression stations due to high unit power and the installed GCU’s. Hence, the major problem
with the compression complex is the decrease in the utilization of the equipment lower than the
nominal capacity.

While the extraction output of the Cenomanian deposits was decreasing, the extraction of
the Valanginian pool remained stable. The design solutions at these fields included the launch
of compressor facilities and application of exploitation strategies at the first stage of BCS-GPP
and the second stage of BCS-BCS-GPP [9, 10]. Gazprom Dobycha Urengoy LLC developed
processes of joint exploitation of Cenomanian and Valanginian pools, which helped to improve
the process of preparation of gas and condensate at the Valanginian GPP’s by using the GPP-
BCS gas compression scheme. Gas compression was carried out by supplying the separation
gas to the Cenomanian BCS, which optimized the operation of five compression stations of the
Cenomanian GPP’s. A considerable benefit of the implemented technological solutions was the
suspension for several years of the launch of the Valanginian BCS’s and a reduction of their
capacity [9–12].

The experience of joint exploitation of the Cenomanian and Valanginian pools was used to
design technological solutions for joint development of Cenomanian deposits [4, 13]. Gas from
satellite fields is piped to the main hub where it is prepared up to the normative requirements
and compressed for transportation.

At present, the Valanginian deposits are in the phase of decreasing extraction output, which
leads to freeing up of capacities for gas preparation and compression. To maintain the level of
hydrocarbon production in the conditions of declining output of the Cenomanian and
Valanginian pools, Gazprom Dobycha Urengoy LLC started the development of the Achimov
horizon of the Urengoy field [14–16]. The design solutions for the GPP’s on Achimov deposits
envisage construction of 6 GPP’s for gas preparation at the 5 Achimov sites (1A-5A) (Figure
2). In case formation pressure decreases, it is planned to launch the first and the second gas
compression units at every GPP [5].

In 2008, German-Russian Achimgaz CJCS commenced pilot production from the first site
(GPP-31), and in 2009 Gazprom Dobycha Urengoy LLC launched the production at the second
gas and condensate development site (GPP-22) [17, 18].

The fluid processing using low temperature separation was used as the basis for
hydrocarbon preparation processes at the GPP-22 and 31; technological solutions used here
were similar to the gas preparation process at the Valanginian GPP’s [19–21]. The designs
envisage similar technological solutions at the Achimov GPP’s that are to be launched. The
designing and launching of the first and the second sites of the Achimov deposits were carried
out at the time when the Urengoy gas and condensate fields were being exploited at a high
capacity utilization level. Therefore, the possibility to use the LTC equipment of the
Valanginian deposits for supplying Achimov gas was not considered. However, the expected
freeing up of the capacities of the Urengoy Valanginian deposits opens up new opportunities to
use the existing infrastructure to prepare gas from the Achimov horizon.
2. MATERIALS AND METHODS

The results of surveying the Achimov and Valanginian wells of the Urengoy field were used as the raw data on the formation gas composition. To prognose the changes in the formation gas composition, calculations of phase equilibriums of gas-condensate mixtures and simulation of technological procedures using the applied thermodynamics methods were carried out. Technological modeling of the operation of the complex ‘gas gathering network – GPP - interfield pipeline’ was carried out in the GazKondNeft software system using the multivariate combinations of preparation processes, thermobaric and pressure-flow parameters. The adaptation of the technological model of the LTS unit was carried out based on the results of the field survey of the GPP-1AV equipment efficiency.

3. RESULTS

The Valanginian deposits of the Urengoy oil, gas and condensate field have higher initial formation pressure in comparison with the Cenomanian. The relatively moderate rate of gas extraction from the Valanginian deposits enabled their development with a practically stable extraction level, maximum extraction level was reached in 2004. At present, the pressure of formation gas piped to the Valanginian GPP’s is varying from 3.5 to 5.0 MPa. The Figure 3 represents a flow diagram of the Valanginian LTS unit [12].
The formation gas is undergoing primary separation and is piped to the booster compression station. After the pressure has increased and the gas has been cooled in the air-cooling device, it is separated in three levels with cooling the gas in heat exchangers and with the help of an ejector. Separated gas, after heating in heat exchangers, is removed from the station and is piped to the second compression stage of the nearby Cenomanian booster compression station. Whereas the liquid from separators is piped to separators R-1 and 2 and the buffer tank for the separation into hydrocarbon, water and gas phases. The unstable condensate is piped from the unit to the central condensate pumping station and the Condensate Pre-Transportation Preparation Plant. Water and methanol mixture with 70% wt. methanol concentration from the R-2 separator and buffer tank is used to inhibit the plumes of the Valanginian fields; and the mixture with 10% wt. methanol concentration from the R-1 separator at the GPP-1AV and 5V is piped to the methanol regeneration facility; at the GPP-2V and 8V it is pumped into the formation. The drained gas from R-1 and R-2 separators and the buffer tank is utilized with the help of the ejector.

In comparison with the peak level, the extraction of the Valanginian gas has slightly decreased to date. The Table 1 presents the data on the capacity utilization of the LTS equipment and gas compressor units at the Valanginian GPP’s of the Urengoy field. As can be seen from the chart, the GPP-2V has the lowest capacity utilization of gas preparation equipment, with other GPP’s capacity utilization is 72-98%. It should be noted that the GPP-1AV has the highest number of gas preparation production lines. Loading of gas compressor units is minimal at the GPP-2V and 8V, and with the GPP-1AV and 5V it is 38 and 47%, respectively. Furthermore, the compression stage before the Valanginian GPP’s is equipped with 4 gas compressor units at the GPP-1AV and 2V; and 3 gas compressor units at the GPP-5V and 8V.
Table 1 Number of production lines and GCU’s at the Valanginian GPP’s of the Urengoy filed and their capacity utilization

<table>
<thead>
<tr>
<th>GPP</th>
<th>Number of production lines items</th>
<th>Number of LTS facilities units</th>
<th>Capacity utilization of production lines %</th>
<th>Number of GCU’s units</th>
<th>Power of BSC* MWt</th>
<th>Capacity of utilization of BSC %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1AV</td>
<td>8</td>
<td>2</td>
<td>54.4</td>
<td>4</td>
<td>30</td>
<td>37.5</td>
</tr>
<tr>
<td>2V</td>
<td>6</td>
<td>3</td>
<td>36.4</td>
<td>4</td>
<td>30</td>
<td>24.2</td>
</tr>
<tr>
<td>5V</td>
<td>4</td>
<td>2</td>
<td>70.3</td>
<td>3</td>
<td>20</td>
<td>47.1</td>
</tr>
<tr>
<td>8V</td>
<td>7</td>
<td>2</td>
<td>70.9</td>
<td>3</td>
<td>20</td>
<td>27.4</td>
</tr>
</tbody>
</table>

The design solution envisage a decrease in gas extraction in the future, which will lead to lower capacity utilization of LTS production lines (Figure 4). In the connection with lower loading of the Valanginian GPP’s, the possibility of using their capacities to prepare gas from the Achimov horizon was elaborated. According to the development project, the commissioning of the GPP-30 at the 3A site of the Urengoy field is not foreseen earlier than 2028. The units located in the closest vicinity to the GPP-30 are the GPP-1AV (about 10 km) and GPP-2V (about 20 km). Up to 2028, capacity utilization of LTS equipment at the GPP-1AV and 2V will have fallen to 40.8 and 23.7%, respectively.

![Figure 4](http://www.iaeme.com/IJMET/index.asp)  

**Figure 4** Outlook of the capacity utilization of LTS production lines

Therefore, the possibility was considered to prepare the gas from the 3A site using the capacities of the GPP-1AV and 2V that will free up in the future. The pressure of the Valanginian gas after passing the booster compressor station, at the entry to the LTS facilities, is up to 7.4 MPa. Separated gas with 3.0 MPa pressure is mixed with the Cenomanian gas and compressed during the second compression stage by the nearby Cenomanian BCS to be further supplied to the interfiled pipeline. The initial input pressure of the Achimov gas for the low temperature separation will be 11.0 MPa, while the output pressure of separated Achimov gas will suffice to pipe it to the interfiled pipeline (5.0 – 5.5 MPa). Consequently, joint preparation
of the Valanginian and Achimov gases at the Valanginian GPP should include the following stages:

1) separate frameworks for the preparation of the Valanginian and Achimov gases at the dedicated production lines of the Valanginian GPP before the compression stage for the Achimov horizon gas;

2) joint exploitation of the Valanginian and Achimov gases by mixing them before piping to the LTS facility or before compression at the Valanginian booster compression station.

The Figure 5 presents the outlook for the capacity utilization of the GPP-1AV and 2V production lines when used for preparation of the Valanginian and Achimov gases. As can be seen, the Achimov gas can be piped to both processing plants. Capacity utilization can reach the maximum of 71.6% for the GPP-1AV and 78.3% for the GPP-2V.

![Figure 5](image-url)

**Figure 5** Outlook for the capacity utilization of LTS production lines of the GPP-1AV and 2V when used for preparation of the Valanginian and Achimov gases

Given the need for separate preparation of the Achimov and Valanginian gases at the first exploitation stage, the more processable option would be piping the Achimov gas to the GPP-1AV. The reason for that is the configuration of the processing unit, which consists of two low temperature separation production facilities with 4 gas preparation production lines in each of them. At the first stage, the Valanginian and Achimov gases will be processed in different facilities, while at the second stage both facilities will prepare the mixture gas. In the case of piping Achimov gas to the GPP-2V, there is a need to share the Valanginian and Achimov gases between the three facilities with 2 production lines, which is technologically more difficult than separate piping of gas to two facilities. A significant advantage of piping the Achimov gas to the GPP-1AV is shorter distance between this plant and the 3A site.

The presence of refractory paraffin in the formation gas of the Achimov deposits limits the possibilities of its transportation from the Valanginian GPP’s via the existing condensate pipe [22, 23]. The first reason for that is the limits of the Condensate Pre-Transportation Preparation Plant (CPTPP) regarding receiving paraffin-containing material [24–26]. At present, because
of the high capacity utilization of the CPTPP, it is impossible for the plant to process additional heavy gas from the Achimov deposits. In this connection, Gazprom Pererabotka LLC is currently constructing a condensate stabilizer unit (CSU) to prepare the gas from the Achimov deposits for transportation. The development of the new Achimov fields will be synchronized with putting the CSU in service. However, given the rates of hydrocarbon extraction decrease at the Valanginian deposits and the technical specifics of CPTPP equipment, a need for additional loading of the processing equipment with light condensate will appear in the future. The second reason is the temperature of transportation of the Valanginian condensate - about 0°C, which facilitates the release of heavy paraffin from the Achimov condensate. The temperature of condensate transportation from the Achimov GPP’s is not lower than 25°C, which is reached by heating the condensate at the GPP in the gas-condensate heat exchanger and by heating the condensate by track heaters.

Similarly to the Valanginian gas processing at the Yamburg field with the use of pre-preparation gas plants and final gas preparation at the main GPP […], it is suggested (Figure 6):

- instead of the GPP-30, to construct a pre-preparation gas plant (PPGP-30) with minimum of necessary production equipment, i.e. slugcatchers and primary separators;
- to transport paraffin-containing unstable condensate from the PPGP-30 via the pipeline of 273 mm in diameter and 26.5 km long to the condensate stabilizer unit of the Gazprom Pererabotka LLC for preparation to transportation;
- to pipe the primary separation gas from the plant by the gas pipe of 720 mm in diameter and 10.5 km long for the final preparation at the GPP-1AV;
- to use the existing capacities of low temperature separation, the Valanginian booster compressor stations of the GPP-1AV and of the second compression stage of the Cenomanian BCS of the GPP-1AS.

Figure 6 Flow diagram of transporting hydrocarbons from the PPGP-30
Initially, the separated gas from the 3A site is piped to one of the facilities of the GPP-1AV for the preparation at the low temperature separation unit. After LTS, the gas is supplied to the interfiled pipe, and the ‘light’ Achimov condensate - to the separator facility, where it is to be mixed with the Valanginian unstable condensate. The transportation of the mixed condensate should be carried out via the existing condensate pipeline from the GPP-1AV to the condensate pumping station, from where it is delivered to the CPTPP. The additional condensate from the Achimov horizon supplied to the GPP-1AV will help to partially compensate for the continuously decreasing amount of liquid hydrocarbons of the Valanginian deposits as well as to maintain the optimal capacity utilization of the CPTPP process equipment.

Further, compression of the Achimov gas will be needed in order to comply with the parameters of the LTS process. We suggest using the freed up capacities of the GPP-1AV booster compressor station by mixing the Valanginian and Achimov gases and joint gas preparation in the two GPP-1AV facilities. Due to this, capacity utilization of the BCS will rise to 70%, which will help to exclude from the project the commissioning of the 3A site Achimov compressor facilities and ensure optimal capacity utilization for the Valanginian GCU’s, and this in its turn will reduce fuel gas consumption.

4. DISCUSSION
The development of the sites of Achimov horizon of the Urengoy field requires considerable capital investment for the construction of gas processing plants. The conducted analysis of capacity utilization of the equipment of the Valanginian sites has shown that the pressing issue is freeing up of capacities of production lines of LTS units and GCU’s. The author has suggested technological solutions how to optimize capacity utilization of the Valanginian GPP-1AV equipment by using its capacity to prepare the gas from the 3A Achimov site. The scheme was elaborated regarding joint preparation of the Valanginian and Achimov gases, where paraffin-containing Achimov condensate is separated from the gas during the primary separation stage at the PPGP-30; whereas separated gas is delivered to the Valanginian GPP-1AV for joint processing. Stages of joint gas preparation were developed taking into account different input pressure of the Valanginian and Achimov gases at the GPP-1AV. The compression of sales gas of the GPP-1AV is to be carried out at the second compression stage of the Cenomanian GPP-1AS. Due to the developed schemes of joint gas processing, the construction of the GPP-30 and a BSC with two compression facilities for the Achimov gas is no longer needed. Moreover, the production of light condensate from the Achimov deposits formation gas can partially compensate for the reduction in the supply of unstable condensate from the GPP-1AV to the CPTPP.

5. CONCLUSION
In this way, Gazprom Dobycha Urengoy LLC is carrying out systematic work to develop and implement innovative technological solutions based on the effective use of the existing equipment capacity, which will facilitate the optimization of gas and condensate preparation process. The use of compression capacities of the Cenomanian and Valanginian GPP’s to compress the gas extracted from the Achimov deposits in the future will help to avoid the construction of a GPP and a BCS at the third Achimov site. The developed technological solutions enable the company to raise the profitability of the project by minimizing the construction of key production assets, reducing further operating costs and optimizing the capacity utilization of the Urengoy oil, gas and condensate field
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http://www.iaeme.com/IJMET/index.asp 1071 editor@iaeme.com
