Key factors reducing energy consumption in gas supply

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Abstract. The article covers the key factor reducing energy consumption in gas-transport systems of Republic of Uzbekistan when transporting natural gas, increasing the efficiency of gas pipelines during operation and rational using of energy costs, solving a number of environmental problems by effectively cleaning the internal cavity of gas pipelines from various contaminants.

1. Introduction
At present, development of the gas industry in Republic of Uzbekistan largely depends on the further improvement of operation and maintenance of compressor stations of the gas-transport system for the transportation of natural gas.

In view of the rise in energy prices and the cost of gas transportation, taking into account the absence of renewal of its natural resources, the main directions of research in the field of gas transportation should be research aimed at reducing energy consumption and increase the saving in this field.

Optimal operational mode of main gas pipelines consists in the fact that the maximum use of their rate of flow with a minimum of energy consumption required for pumping and transporting gas through gas pipelines [1].

Finished product is dry natural gas that meets the technical requirements for combustible natural gases supplied to the main gas pipeline from the underground gas storage “Gazli” Unit of gas-main pipeline and transit gas according to O’zDst-948:1999 (table 1).

| Name of indicators | Unit | Standard O’zDst-948:1999 | Experiment method |
|--------------------|------|--------------------------|-------------------|
| Moisture gas dew point, no more | °C | Summer: 0 Winter: -5 | O’zDst - 948:1999 |
| Hydrogen sulfide mass, no more | g/m³ | 0.007 | GOST 22387.2-97 |
| Mercaptan sulfur mass, no more | g/m³ | 0.016 | GOST 22387.2-97 |
| Oxygen volume fraction, no more | % | 0.5 | GOST 22387.3 |
| Mechanical impurities mass, no more | g/m³ | 0.001 | GOST 22387.4 |

According to physical-chemical indicators, natural combustible gases must correspond to the requirements and standards. According to their toxicological characteristics, natural combustible gases are classified as substances of hazard class 2.
Gas (methane) is colorless, odorless, and is lighter than air. Explosive concentration is formed when the content of natural gas in the air is from 4 to 16%.

Natural gas accumulated in enclosed space displaces air and has a choking effect on the human body. Choking can occur when the air contains 20% gas. The maximum permissible concentration (MPC) of gas in the air is 0.7%.

2. Methods

“Gazli” Unit of gas-main pipeline is designed to prepare gas for further transportation, which includes its purification in mechanical purification separators, dust collectors and gas compression, i.e. increasing its pressure by successive compression on the impellers of the gas compressor unit. Because of the execution of the compression work, the gas is heated after each compression ratio, and then is cooled by the gas air-cooling device.

“Gazli” Department of gas-main pipeline consists of: UGS (underground gas storage), head structures, and the linear part of the main gas pipelines.

The technological scheme of the compressor station provides for the following main processes in the technological scheme of the “Gazli” compressor station: gas purification, gas compression, gas cooling, a fuel gas system, starting and pulse gas, a lubricating oil supply system and gas metering.

Improving the operating efficiency of gas-pumping units is inextricably linked with the provision of the necessary energy-saving technology for gas transportation, diagnostics of the installed energy-saving gas-compressor unit equipment, the choice of optimal operating modes for its operation and further technical operation of gas pipeline systems.

A typical view of the graphs of the variable mode of operation of the gas pipeline with a change in its productivity is shown in table 2.

Table 2. Seasonal fluctuations in gas consumption in a large industrial center (gas consumption K, million m³/day).

| Months | A  | B  | C  | D    |
|--------|----|----|----|------|
|        | Central heat station | Industry | Heating | Household consumers |
| 1      | 14 | 18 | 3  | 5    |
| 2      | 12 | 17 | 3  | 6    |
| 3      | 10 | 15 | 2  | 5    |
| 4      | 9  | 13 | 1.5| 4    |
| 5      | 9  | 6  | 1  | 3    |
| 6      | 8  | 5  | -  | 4    |
| 7      | 7  | 5  | -  | 4    |
| 8      | 6  | 4  | -  | 2.5  |
| 9      | 9.5| 5  | -  | 3    |
| 10     | 10 | 13 | 1.5| 4    |
| 11     | 12 | 17 | 2  | 5    |
| 12     | 14 | 18 | 3  | 6    |

From table 2 it can be seen that the greatest influence on the operating mode of the compressor station and individual gas compressor units is exerted by seasonal changes in the gas pipeline productivity. Typically, the maximum gas supply falls on December-January, and the minimum is in the summer months of the year [2].

Rational operation of compressor stations depends on the type and number of gas compressor units (GCU) installed at the stations, their energy indicators and technological modes of operation.

At present, oil face seals are installed in many gas compressor stations. Dry gas dynamic seals can be installed on the centrifugal compressor as a seal. The main advantages of gas seals are the elimination of oil contamination of the compressed gas; oiling of the flow path of the compressor and pipelines is highly undesirable for technological processes.
Therefore, because of gas pollution with oil, the rate of flow of the gas pipeline is reduced by 1-2%. When using mechanical oil seals, the presence of high-pressure oil, in addition, can lead to oil leaks in the compressor compartments and reduce the overall environmental friendliness of production [3].

Currently, the most widespread at the fields are compressors and gas compressor units of the following types: gas-engine, turbocharger and rotary with an electric drive.

Gas-engine compressors are piston-type compressors connected in one unit with an engine (gas motor) that uses the pumped gas as fuel.

If the gas is pumped over short distances, i.e. high pressure is not required, and then turbochargers or rotary ones driven by an electric motor are used. The turbocharger is a centrifugal machine with a rotational speed of up to 14,000 rpm.

Rotary compressor, unlike a turbocharger, works on the principle of reciprocating machines, but differs from them in that the gas is not compressed during the reciprocating movement of the piston, but because of the rotational movement of the cylindrical piston, called the rotor.

The advantages of turbochargers and rotary compressors in comparison with reciprocating ones include small dimensions and weight; simplicity of design; poise of the machine; direct flow of the process and uniformity of gas supply.

The disadvantages of these compressors include increased requirements for the accuracy of manufacturing and operation. Recently, screw compressors are increasingly used for compressing end-stage gases or hot vacuum separation. Unlike those described above, screw compressors, according to the principle of operation, belong to the type of volumetric (piston) machines that allow pumping gas-liquid mixtures, i.e. gas with some liquid phase content.

Key factor in reducing energy consumption during gas transportation is timely and effective cleaning of the internal cavity of the pipeline from various types of contaminants.

This problem, which is important for the industry, can be solved both by introducing new generation gas-pumping units with an efficiency of 34-36%, and by increasing the efficiency of using various types of gas-pumping units installed at compressor stations [4,5].

3. Results
The internal state of the needle tube has a great influence on the change in energy consumption associated with overcoming the forces of hydraulic resistance in the inner cavity of the needle tube. The creation of highly efficient treatment facilities with a large engine resource will allow maintaining the efficiency of the gas pipeline at the project level, reducing energy consumption by about 10-15% [6,7].

Research show that the composition, physical and chemical properties of the transported gas and the parameters of its transportation, as well as the hydraulic properties of the transport pipeline affect the operation of the compressor station and lead to increase or decrease in the consumed energy (Table 3).

| Change in energy consumption, % | Difference in temperature, °C | Difference in pressure, MPa | Molecular mass of gas, g/mole | Roughness, mm |
|-------------------------------|-------------------------------|----------------------------|-----------------------------|-------------|
| 2                             | 2                             | 0.3                        | 16.6                        | 0.5         |
| 5                             | 4                             | 0.5                        | 17.2                        | 0.9         |
| 7                             | 6                             | 0.8                        | 17.3                        | 1.2         |
| 9                             | 8                             | 0.9                        | 17.5                        | 1.3         |
| 11                            | 10                            | 1.1                        | 17.6                        | 1.6         |
| 12                            | 12                            | 1.4                        | 17.8                        | 1.8         |
| 14                            | 15                            | 1.7                        | 17.9                        | 1.9         |

Variable operating mode of the compressor station leads to a decrease in the load of gas-pumping units and, as a consequence, to an overconsumption of fuel gas due to deviations from the optimal efficiency coefficient of the GPU.

With an increase in the rate of flow of gas pipelines due to an increase in the diameter of the pipe and the working pressure, the temperature of the gas flowing through the pipeline increases. To increase
the efficiency of the gas pipeline and, above all, to reduce the capacity for gas transportation, it is necessary to install gas air cooling devices at the outlet of each compressor station. Lowering the temperature is also necessary to maintain the pipe insulation [8,9].

In order to reduce the power consumption of the compressor station for pumping gas, to increase the rate of flow of the gas pipeline and to save energy resources for pumping gas, it is always beneficial to maintain the maximum gas pressure in the pipeline, reduce the temperature of the pumped gas by cooling it at the stations, use gas pipelines of larger diameter, and periodically clean the internal cavity of the pipeline. The obtained results of the dependence of the $n$ coefficient on the diameter of the gas pipeline (Dy) are shown in figure. 2.

![Figure 1. The graph of dependence of $n$ coefficient on the diameter of the gas pipeline (Dy).](image.png)

Gas at the inlet of booster compressor station-2 is supplied through taps No. I, II, III, IV, I, IV a with cleaning from liquid and mechanical impurities on dust collectors. At the inlet of “Gazli” compressor station, oil vertical dust collectors are installed. Vertical oil dust collectors, which are vertical cylindrical vessel with a spherical bottom, provide high purification of gas from solid suspension.

In dust collectors, the gas to be cleaned passes through the inlet to the gas flushing section and is directed to the contact gas flushing tubes, the lower end of which is located 20-50 mm above the oil level.

In the contact tubes, the gas is thoroughly washed, cleaned of dust, and then, together with drops of the washing liquid containing a solid suspension, is thrown into the settling section. In the sediment section, because of a decrease in the gas velocity and the action of gravity, large drops of flushing liquid and solid particles fall out, which return through the drainpipes to the lower section of the dust collector for sediment [10].

The gas, cleaned of large droplets of flushing liquid, enters the scrubber section, where it is finally separated. Slime settled on the bottom of dust collector is periodically removed through the hatch. Contaminated flushing liquid is also periodically removed from the dust collector to the sump.

According to the results of research, it was established that ensuring the efficient operation of gas compressor units is achieved by cleaning axial compressors with cleaning solutions [11].
The diagram from figure. 2 shows the power parameters of technical condition of the gas distribution devices before cleaning the axial compressor and the optimal process parameters were determined.

![Diagram showing the dependence of the value of $C_p D_h$ on pressure $P$ and temperature $T$ for natural gases of the first (dotted line) and second (solid line) compositions.]

**Figure 2.** Dependence of the value of $C_p D_h$ on pressure $P$ and temperature $T$ for natural gases of the first (dotted line) and second (solid line) compositions.

In this case, the relative value of the power of the unit is:

\[
(N_{e,p}) = \frac{N_e}{N_{e0}} = \frac{4082}{6150} = 0.66
\]

Thereby, the power parameters of technical condition of the gas distribution device before flushing the axial compressor is:

\[
K_N = (N_{e,p})/N_{e,pr.} = \frac{0.66}{0.78} = 0.85
\]

Technical condition coefficient of the unit in terms of capacity increased from 0.85 to 0.9 because of the “flushing” of axial compressor.

Key factor in reducing energy consumption during gas transportation is timely and effective cleaning of the internal cavity of the pipeline from various types of contaminants.

**4. Conclusions**

Because of research, the following conclusions were made:
• It has been established that the key factor in saving the energy consumption when pumping gas is timely and effective cleaning of the internal cavity of the pipeline from various types of contamination, which leads to a decrease in energy costs associated with overcoming hydraulic resistance in the internal cavity of the pipeline.

• To reduce the power consumption of the compressor station for gas pumping, increase the throughput of gas pipelines and save energy consumed for pumping gas, it is recommended to maintain the maximum gas pressure in the gas turbine pipeline, reducing the temperature of the pumped gas due to cooling at the stations, and cleaning the internal cavity of gas pipelines.

• To ensure efficient operation of gas transportation units, it is recommended to clean the cavity of gas pipelines and an axial compressor.

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