E3S Web of Conferences **592**, 04003 (2024) https://doi.org/10.1051/e3sconf/202459204003
EMMFT-2024

Energy indicators of the gas supply system during gas storage and use

A.L. Petrosyan[1*]

[1] National University of Architecture and Construction of Armenia, Chair of ventilation, Пas and Peat supply, Erevan 0009, Armenia

Abstract. Below are the measures to be taken in case of gas storage.They have energy-economic justifications,are based on a comparison of costs incurred for storing natural gas in underground wells and the cost of stored gas.Three comparable options were considered,the comparison of which revealed the most expedient option:supplying gas to wells by pressing it in two- or three-stage compressors equipped with an electric motor, and in the case of re-use of gas, when the pressure is reduced - decompression, it is carried out not by throttling, but by the thermodynamic process of expansion in the detander.This will restore 35 ... 50% of the electricity consumed in the compression process.If there are sufficient volumes of natural wells, lower the final pressure, for example 6.3 MPa, thus saving significant energy and money.

1 Introduction

In many countries where natural gas is supplied centrally from a single source, such a gas supply system has a number of problems.First of all, the price of gas, which depends on the economic, in some cases political demands of the supplier, fluctuations in prices in the international fuel market, can increase periodically (a decrease is not ruled out).Besides, due to the continuity of the gas supply process, there is a need for underground natural gas storage wells.This can increase the price of gas supplied to the population by 10 ... 15%, especially in the case of central wells.In other ways, especially in the case of decentralization, it can be done in artificially created spaces, but only for the needs of those dwellings.In this case, there is a need for serious analysis, consideringthe technical and economic requirements.Armenia is in a similar situation.Receiving gas only from Russia, regardless of the prices set in the world energy market, the price of gas is determined by mutual agreements.At present, centralized gas storage is carried out in Armenia in the Abovyan underground gas storage, in our opinion, at a rather high pressure of 12.5 MPa.

As mentioned in [1], the transport of gas by the method of increasing the pressure for thousands of kilometers - 22 ... 40 MPa, when it is carried out through large diameter main gas pipelines, then such high pressures can create high volumetric productivity by compressing gas - developing high pressure in multistage compressors.Various forms of energy and energy resourcesare used for this purpose, when gas internal combustion

* Corresponding author: artashespetrosyan@mail.ru

enginesor asynchronous or synchronous electric motors are used for compressors.In the first case, natural gas is used, in the second case, electricity. Gas internal combustion engines have a low coefficient of thermal efficiency - a maximum of 0.15 ... 0.18, are metal-bearing, both compressors and gas internal combustion engines, do not have modern technical capabilities to regulate volumetric productivity.The results of such a study are presented in more detail than below, in [2].In the case of electric motors, the presence of reserve and peak capacities in the power system is mandatory.The energy efficiency of the gas storage process as well as the transport process will be increasedif, before gas consumption, when it is necessary to reduce the gas pressure (decompression), the irreversible throttling process is replaced by a polytropic expansion process in the "detander-generator" type installations [3]. This will restore about 40 ... 50% of the energy expended in the compression process, when the pressure energy transmitted to the gas is converted into mechanical energy in the detander, and in the generator connected to it - into electricity.

This will increase the thermodynamic and exergetic efficiency of the gas storage and transport process.However, as a result of the expansion process, the gas parameters - temperature, specific volume - will be significantly reduced. Therefore, in some climates, especially during the winter months, it is necessary to heat the expanded gas using natural or artificial means.Similar studies have been performed [4], when the gas stored in the wells is expanded before consumption in the detander-generator type installations. However, it should be noted that in the case of reuse of stored gas, as in gas distribution companies, there are gas losses. Losses occur at gas regulation points in buildings or wells in the amount of 50 and 51%. According to [5], losses occur even after prolonged exploitation of underground gas wells by emission and hidden flows to the inner, upper layers of the ground. Gas leakage occurs due to vertical-horizontal fractures in the geological depth. The gas in the well is exposed to diffusion-convective currents and tends to the outer surface of the soil and is emitted to the biosphere. This phenomenon becomes more significant at high gas pressures when the pressure approaches or exceeds the maximum permissible strength of fastness of the ground layers. A similar conclusion is made in [6]. Very often, depending on the seasonal changes in gas volumes, in case of its relocation, it is necessary to regulate the volumetric productivity of the main compressor station [7]. If they are mobile, in particular gas turbine installations, this is done by adjusting the rotational frequency of the rotors.As mentioned in [8], it is advisable to implement it through special programs, fulfilling the requirements set out in [8,9]. If synchronous electric motors are used, it is organized by adjusting the speed of the synchronous electric motor by changing the voltage in the mains by means of inverters. In order to increase the energy efficiency of gas storage, special attention should be paid to the process of cooling the gas in air-cooled heat exchangers after compression in individual stages of the compressor.This was addressed in [10 and 11], in particular in the case of gas cooling in 2AVG-75C heat exchangers.In order to increase the energy efficiency of gas storage, it is necessary to ensure the energy-efficient operation of the main auxiliary equipment included in the used compressor station according to the requirements of [12,13,14].

A study of literary sources, real life shows that no matter how large the capacity of gas pipelines, it is difficult to meet the demand for gas in homes where the heat demand for heating can increase sharply, even reach prices, and even accidents in highways or compressor stations are also possible. This will mean that there is a need for additional volumes of gas, which, in case of minimum gas demand, for example in summer, will be used to store the necessary volumes of gas. In particular, underground gas storage facilities have been built and are widely used on the main pipeline supplied to the European Union in Ukraine and Austria. In Russia, such technologies are used to ensure uninterrupted gas supply to certain regions [14a]. In particular, according to [14b], the Mozir underground gas storage facility has been operating since 2014 to prepare for the autumn ... winter season.In [15] similar materials are presented on the expansion of the Kaliningrad underground gas storage station.

2 Materials and methods

There are similar underground gas storage facilities in Armenia in the area of Ptghni village near Yerevan.It aims to provide uninterrupted gas supply to residential and industrial consumers in the country for a period of 1 week.In the former Soviet Union, the state paid for gas storage costs. Now, when these costs are divided by the volume of gas consumed by consumers, the cost of gas storage is included in the gas tariff.The problem is complicated by the different tariffs on gas consumption.In particular, the tariff for the population is 139 AMD/m^3 = $ 0.29 / m^3, and for industrial enterprises with consumption volumes of 10000m^3 - 11621 AMD / 1000 m^3 = $ 242.1 / 1000 m^3.This means that there is some difference between the gas tariffs provided to consumers, so the cost of storage is different for them. From 2018 November ... to March, in Armenia a maximum of 9500 thousand m3/ day gas was spent, and the minimum - 4000 thousand. m3/day gas. During the summer months, these numbers are respectively - 6800 and 1100 thousand m^3/day. It follows that the tariffs are different during the winter months, when 40% more gas is consumed. The latter will mean that the winter season is crucial for gas storage, both in terms of volume and danger, especially in terms of providing the population with life and a normal microclimate. The storage of natural gas in one of the central gas storage facilities is not always strategically and technically expedient, as there is a risk of those wells being blown up and decommissioned, as well as the distribution of that gas throughout the country after de-storage. There is a problem of decentralization of gas wells by regions and settlements. If possible, they should be located separately near large and medium-sized settlements, maintaining appropriate safety and sanitation standards, if appropriate ground rocks, deep wells. The compressors used for gas storage in Armenia are horizontal cylinders, three-stage with small crankshaft pulleys and large wheels, reciprocating compressors are connected to the gas internal combustion engines.Having a huge metal mass, these engines have a high energy demand, which leads to high specific fuel consumption, maintenance, repair, complexity of finding spare parts, limited interchangeability. As a result, all of this leads to a significant increase in the cost of gas storage. If in the past it affected the state budget, now the population pays for it. The way out of this situation is the replacement of physically and morally worn-out technological equipment with modern ones, and, if possible, the decentralization of gas storage facilities. Studies have shown that the following actors need to be considered to reduce the cost of gas:

The gas internal combustion engines replace with electric motors,

gas storage, instead of 12.5 MPa, perform at lower pressures of 6.3 MPa

When reusing the stored gas, when it is necessary to reduce the pressure from 12 to 1 ... 1.2 MPa, instead of the irreversible process of throttling, carry out an expansion process close to the irreversible, using the "detander-generator " installation.

Decentralized gas storage, if there are appropriate natural conditions, deploy storage facilities near settlements, and determine storage volumes according to specific volumes of natural gas per capita in winter months, number of settlements,to the type of heat source for heating and hot water supply in the dwelling, use decentralized or centralized systems.

To assess the impact of these factors, make economic calculations, consider the costs and the specific cost of gas as an indicator.

This would mean replacing old technological equipment with new ones, using electric motors instead ofthe gas internal combustion engines. [16] is dedicated to such issues. Three comparable versions were considered in it.

The gas internal combustion engines as a three-stage reciprocating compressor drive, and in case of reuse of stored gas, the pressure reduction is carried out due to a multi-stage throttling process, throttle pressure drop regulators are used.

Intermediate option, when the three-stage reciprocating compressor receives mechanical energy from the electric motor and the pressure is reduced as before.

The most energy-efficient and modern version: the three-stage reciprocating compressor receives mechanical energy from the electric motor, and the pressure reduction is carried out with the help of a "detander-generator".

High-pressure gas storage in natural wells requires two- or three-stage compressors, for which the source of mechanical energy can be the gas internal combustion engines and the electric motor [16]. In case of reuse of the stored gas, the gas taken from the wells is now subjected to multiple throttling up to the pressure of 1 ... 1.2 MPa maintained in the medium pressure gas pipelines, then the gas pipeline network is given. Such technology is used in Abovyan (Ptghni) gas storage. The process of multiple throttling is both an easy and reliable process, but, from a thermodynamic point of view, it is a very irreversible process, accompanied by huge energy losses, the mechanical work spent in the compression process is completely lost. By using the "detander-generator" installation, it is possible to recover up to 34 ... 37% of the compression energy [3]. Although the setter has a complex structure, little use, it is relatively expensive, especially the piston. Such equipment is manufactured in the USA [17] and they will be used in GPR. They have found similar application in the Federal Republic of Germany. Russia currently manufactures DGA-2500SD1 turbochargers [18]. In order to determine the economic indicators of comparable versions of the storage system, in the case of comparative analyzes, the costs are estimated, which are calculated according to the specific investment values of the equipment used: ` $k_{\text{ICGI}} = 600...700$, $k_{\text{pist.comp..}} = 300...400$, $k_{\text{el.mpt.}} = 150$, $k_{\text{det.}} = 500...750$, $k_{\text{el.gen.}} = 250$, $k_{\text{h.ehch..}} = 120...150$ USD/ kW expenses on preparation and maintenance of natural wells: USD / m3. Prices for other equipment, such as oil separators, separators, etc., have not been taken into account in the calculations, as they remain the same for comparable versions.The quoted costs are determined by the following expression (more details [2]).

$$\sum_{60x24\text{h}} З^{\text{i}}_{\text{nat.g.}} = \left(E_{\text{norm.}} + k_{\text{ren..}}\right) \cdot \sum K^{i}{}_{i} + \sum C^{\text{i}}_{\text{nat.g.}} + SAL. \tag{1}$$

As mentioned [2], the standard and repair coefficients` $E_{\text{nom.}}, k_{\text{ren..}}$ depend on the service term, constitute respectively $E_{\text{ICGI}} = 1/15 = 0.067$,

$E_{\text{comp.}} = 1/20 = 0.05, k^{ICGI}_{ren\ .} \approx 0.3E_{\text{ICGIÞ}} = 0.02, kren.^{comp.} \approx 0.3E\text{comp.} = 0.015$,

$E_{\text{el.m.}} = 1/15 = 0{,}067$,

$E_{\text{gen..}} = 1/20 = 0.05, E_{\text{det.}} = 1/15 = 0.067, k^{gen.}_{ren.} = 0.015, k^{\text{el.m.}}_{\text{ren.}\ .} \approx 0.3E_{\text{el.m.}} = 0.02, k^{\text{det.}}_{ren.} = 0.02$,

$k^{el.m.}_{ren.\ .} \approx 0.3E_{el.m.} = 0.015$

3 Results and discussion

The sizeof $З^{i}{}_{\text{prez.}}$ was determined for different values of the physical volume of the underground well. 50, 90, 150, 200, 250 thousand.m3, to be able to assess the impact of well size on economic performance.

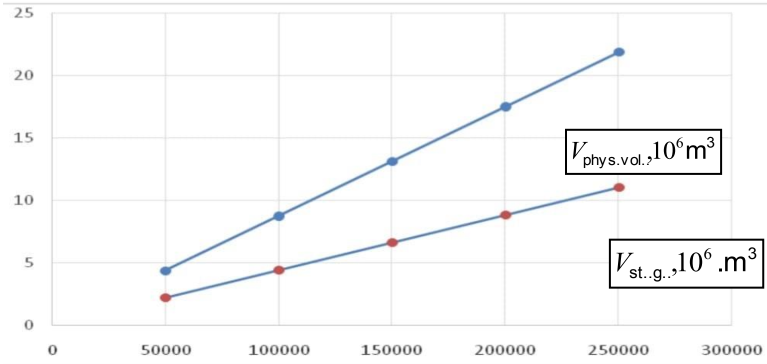


Fig. 1. In the same physical volumes of gas wells $V_{phys,vol.}$, 10^6 m^3, the volumes of gas stored under normal conditions.

Figure 1 shows the volumes of gas stored in the same physical volumes of the gas wells under normal conditions, at a gas pressure of 12.5 and 6.3 MPa. Fig. 1 shows that they are different depending on the final pressure. This is due to the difference in the specific volume of gas filled by the well. This is the reason why specific economic indicators were used in further calculations according to the attributed value of 1 m3 of gas (see Fig. 2). The size off or each version was determined by the installed capacity of the equipment. In the case of the first version, $\sum C_{g.}^{i}$ magnitude was determined by the gas consumption required to meet the needs of the gas internal combustion engines, and in the case of the other versions, by the power consumption of the electric motors of the compressors and their electricity consumption. Based on the size of the normative fuel equivalent of 1 kW of electricity production in the RA power system, the difference in fuel consumption was determined. In the third case, since detanderattached to the detonator generates electricity, in the same way as in the case of cost, the fuel equivalent is determined and deducted from the cost.

Given the costs for each option, such as the amount of gas stored under normal conditions, the cost of gas stored in accordance with the physical volume of the well can be determined. In accordance with the mentioned method, the above-mentioned options were considered under the conditions of storage parameters. The required cost of gas in accordance with the specified physical volumes of the well has been determined. Appropriate schedule have been constructed to compare the cost of gas stored in the observed versions for different physical volumes of the well (see Figure 1). The technical-economic indicators of the comparable options are as follows. When considering the option when the electric motor is running drive and different gas storage pressures: 6.3 and 12.5 MPa then the cost of storage of 1 m^3 of gas increases from 11.14 to 11.54 AMD / m^3 or 3.61%. In addition, the buffer pressure and volume in the well, gas losses, will be significantly reduced. When compared to the results of “the gas internal combustion engines -throttle valve” option, the cost of 1 m^3 of stored gas is AMD 16,086 / m^3 or they are 44.4% higher than the proposed “Electric motor + detander-generator”.

At "Two-stage compressor - electric motor - detander - generator" version and in the case of pressure of 6.3 MPa, the average cost is AMD 9,768 / m^3, which means that it is 14% cheaper than the 12.5 MPa "three-stage compressor - electric motor - throttle valve" option.

As mentioned above, the storage of natural gas at relatively low pressures can be energy efficient, therefore, it is necessary to have a theoretical and practical substantiation. It is necessary to consider the factors, each of which affects the energy efficiency of storage. Gas storage at a pressure of 12.5 and 6.3 MPa can be more or less energy efficient, thus significantly affecting the cost of stored gas, as its compression energy costs are significantly different.

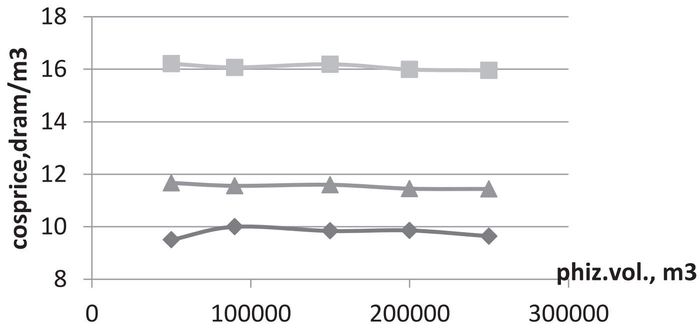


Fig. 2. The cost of gas storage in case of different values and variants of the physical volume of the well if option I or III.

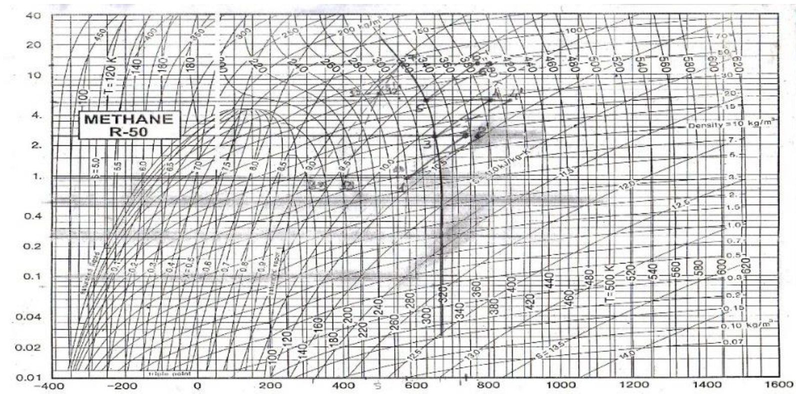
It follows from the calculations that the latter option is more expedient with the use of an electric motor and detander, as the cost of gas storage is reduced not only by the use of the electric motor, but also by the electricity received in the generator operating together with the detonator. As a result, compared to the second option, the cost of gas is reduced by about 18%, and compared to the gas internal combustion engines - by 63.3%.

Thus, based on the results of the above studies, it can be concluded that the cost of gas storage will be significantly reduced as a result of the application of the current version, "electric motor + detander-generator" compared to the current version, "the gas internal combustion engines-throttle valvdiagrames", which will significantly reduce on the cost of natural gas released to the population, it will decrease.This will be economically significant for the population of the republic.

3.1 Thermodynamic study diagrams

The theoretical substantiation of the above is as follows. It follows from the thermodynamic analysis of the diagrams describing natural gas compression processes(see Fig. 3a, b) that in the last stage of the compressor,in the case of large values of the final pressure, the irreversibility of the process increases; the entropy curves that characterize it are wider, so the enthalpy increase or specific work is greater. At 6.3 MPa, these curves increase more rapidly; entropy increases less.

a. Limited to 2–3, 2-$3', 4-5, 4-5', 6-7, 6-7'$ points, with a final pressure of 12.5 MPa and an initial pressure of 1 MPa



b. thermodin. cycle 8-9, point limited, 6.3 MPa final and1 MPa initial pressure

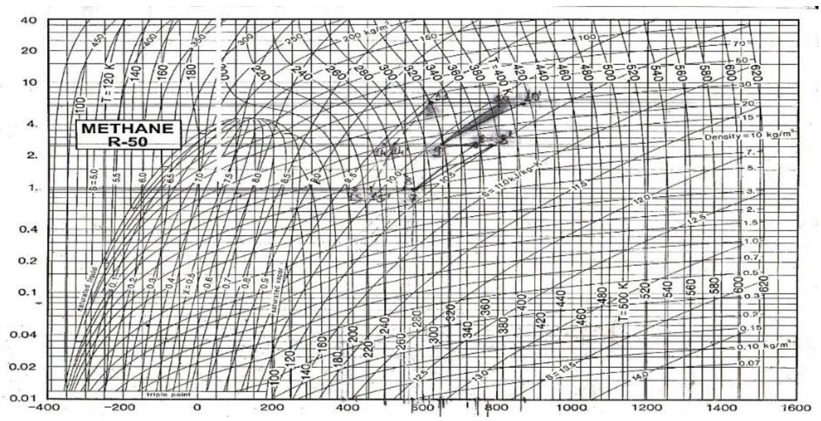


Fig. 3. Description of natural gas compaction processes in the p - i diagram

In the cycles shown in Figure 3, regardless of the final pressures, after compression at each stage of the compressor, the gas is subjected to intermediate cooling by means of the ambient air in the "gas-to-air" heat exchangers when it is pumped through the air.

3.2 Energy performance charts

The actual electric power $l^{i}_{\text{went.}}$ of an air motor is determined by the air quantity V^{i}_{air} and the developing pressure plate $\Delta p_{\text{went..}}$.

Adiabatic and real specific works in the compression processes, their sum quantities, the total specific heat quantities of cooling will be:

$$l_{1-2}^{\text{trist..ad.}} = 170, l_{1-2'}^{\text{three.wal.}} = 227, l_{3-4}^{\text{rist..ad.}} = 150, l_{3-4'}^{\text{hree.w.}} = 208, l_{5-6}^{\text{rist..ad.}} = 145, l_{5-6'}^{\text{hree.w.}} = 207,$$
$$\sum_{i=3} l_{\text{hree.w.}}^{\text{rist...}} = 642, \sum_{i=3} q_{\text{chill.}}^{\text{rist...}} = 657$$

$$l_{7-8}^{\text{trist..ad}} = 160, l_{7-8'}^{\text{hree.w..}} = 213, l_{9-10}^{\text{trist..ad}} = 155, l_{9-10'}^{\text{hree.w.}} = 215, \sum_{i=2} l_{\text{proc.}}^{\text{hree.wї.}} = 428, \sum_{i=2} q_{\text{chill.}}^{\text{hree.w.}} = 398 \text{ KJ / kg}$$

The volumetric air consumption, when the outside air temperature is $35\,^{o}C$, will be determined.

$$V_{\acute{u}^1}^{i}=\frac{\sum q_{chill.}^{i.}}{\rho_{air}^{aw..}c_{air}^{av.}\Delta t},V_{air}^{thre}=\frac{657}{1.131\cdot1.0062\cdot5}=115.5,V_{air}^{two}=\frac{398}{1.131\cdot1.0062\cdot5}=70 \text{ m}^3\text{/kg},$$

The actual specific operation of the pipeline for propulsion of a given volume will be determined by the developing pressure page $\Delta p_{\text{went..}}=150$ Pa, Energy conversion efficiency of airway with the following expressions: $\eta_{\text{went.}}=0.7$

$$l_{went}^{i}=\frac{V_{air}^{i}x\Delta p_{went..}}{\eta_{went.}},\ l_{went.}^{three}=\frac{115.5x150}{0.7}x10^{-3}=24.8,\ l_{went}^{two.}=\frac{70x150}{0.7}=15,\ KJ/Kg$$

As a result, in order for the gas to be compressed to 1 ... 12.5 and1 ... 6.3 MPa, its specific volume will increase from 0.147 to 0.0115 (7 points) and 0.024 (11 points) m3 / kg, for which you will have to spend $\sum_{i=3} l_{gener.act}^{three}$ = 666.8 and $\sum_{i=2} l_{gener.act}^{two}$ = 443 KJ/ kg mechanical work 65 remove 657 and 398 KJ / kg heat.

The three-stage compression volume (m3/ kg) after each step changes as follows: $v_1=0.147, v_{2'}=0.0769,\ v_{4'}=0.038,\ v_{6'}=0.016,\ v_7=0.0115$ After which the ratio of the specific volumes at the input of the compressor and to the output of the third degree is $v_1/v_{6'}=0.147/0.016=9.1$, and after cooling before giving to the wells $v_1/v_7=0.147/0.0115=12.8$ times: 6.3 - in case $v_7/v_{11}=0.147/0.024$ or 6.125 times. As a result, under the conditions of the physical volume of the well $V_{\text{phy.v..}}^{\text{well.}}$, the volume of stored natural gas, brought to normal conditions, will be (see Fig. 1).

$$V_o^{three.}=0.8V_{phy.v..}^{well.}\left(\frac{12.5}{0.1}\cdot\frac{280}{320}\right)=87.5V_{phy.v..}^{well.} \tag{2}$$

$$V_o^{two.}=0.8V_{phy.v..}^{well.}\left(\frac{6.3}{0.1}\cdot\frac{280}{320}\right)=44.1V_{phy.v..}^{well.} \tag{3}$$

Thus, under the mentioned conditions, the cost of mechanical energy will be:

$$\sum N_{pres.+chill}^{thee.}=\frac{V_o^{three.}}{v_7}\sum_{i=3} l_{gener.act}^{three}=\frac{87.5V_{phy.v..}^{well.}}{0.0115}\cdot666.7=5.073\cdot10^6V_{phy.v..}^{well.} \tag{4}$$

$$\sum N_{pres.+chill}^{two.}=\frac{V_o^{two.}}{v_{11}}\sum_{i=2} l_{gener.act}^{two}=\frac{44.1V_{phy.v..}^{well.}}{0.024}\cdot442=0.814\cdot10^6V_{phy.v..}^{well.} \tag{5}$$

It follows from the comparison of the expressions (2) and (3) that, as a result of high pressure and small specific gravity, three times more gas is stored as a result of three-stage compression, and from (4) ŀ (5) it follows that it is obtained as a result of huge energy costs and it is $5.073\cdot10^6V_{phy.v..}^{well.}/0.814\cdot10^6V_{phy.v..}^{well.}=6.23$ as big as low pressure costs. This will mean that at the same volume of gas brought under normal conditions, 6.23 / 2 = 3.12 times more energy will be used to maintain high pressure.

When a gas with a pressure of 12.5 MPa and a temperature of 320 ^oC undergoes expansion in the first degree to a pressure of $p_{av.}=6.25$ MPa, and the irreversibility factor of the process is $\eta_{oi}^{\det.h.pr.}=0.6$, then the gas temperature will decrease and will become $T_{12}^{\text{h.pr.ehp..}}=265^oK$, As there is no need to heat the gas at this temperature, it expands again in the second degree of the detander to pressure of 1 MPa and $T_{13'}^{\text{h.pr.ehp..}} = 210^{o} K$ temperature. As a result of the double expansion, $\sum_{i=2} l_{7\text{-}12'\text{-}13'}^{h.pr.ehp..} = 60 + 105 = 165$ kJ/ kg of mechanical energy will be obtained, part of which will be consumed on the electric motor of the airway, when the low temperature gas will be heated by the surrounding air after the second degree expansion.

$$V_{air}^{h.pr.hest} = \frac{145}{1.273 \cdot 1.0131 \cdot 20.33} = 5.53\, m^3 / kg, l_{went.}^{h.pr.hest.} = \frac{150x5.53x10^{-3}}{0.7} = 1.2\, Kj / kg$$

The result will be mechanical work. $\sum_{j=2} l_{7\text{-}12'\text{-}13'}^{h.pr.com.use.} = 165 - 1.2 = 163.8\ Kj / kg$

It will make 24.6% of the consumed, if the actual energy consumption on the compression gas in the compressor will make: $\sum_{i=3} l_{el.eng.}^{h.pr.usefui} = 666.7 - 163.8 = 502.9$ kJ/ kg.

Similar calculations were made for low pressure. In this case, due to low pressures, we already have: $\eta_{oi}^{\det.low.} = 0.68$, The degree of expansion is again 2, and the gas is heated only after the second expansion. As a result, we have:

$$\sum_{i=2} l_{11-14'-15'}^{lowcom.use} = 75 + 78 - 1 = 152 \qquad \sum_{i=3} l_{el.\det.}^{low\ pr.} = 442 - 152 = 290 \text{ KJ/Kg}$$

In this case, the ratio of already restored and spent mechanical energy will be $\frac{152}{442} x100 = 34.4\%$, which is about 10% more than that obtained for high pressure. This is a consequence of the large efficiency of the expander - 8%, as in other patterns of entropy change in the given diagrams.

The energy costs represented by expressions (3), (4) for comparable variants, considering also the renewed energy, will become:

$$\sum N_{pr.ehp}^{three} = \frac{V_o^{»é.}}{v_7} \sum_{i=3} l_{com.val.}^{three} = \frac{87.5 V_{phy.v..}^{well.}}{0.0115} \cdot 502.9 = 3.826 \cdot 10^6\, V_{phy.v..}^{well.} \qquad (4')$$

$$\sum N_{pr.ehp}^{two} = \frac{V_o^{»ñÏ.}}{v_{11}} \sum_{i=2} l_{com.val.}^{ttwo} = \frac{44.1 V_{phy.v..}^{well.}}{0.024} \cdot 290 = 0.533 \cdot 10^6\, V_{phy.v..}^{well.} \qquad (5')$$

4 Conclusion

Their ratio will be 7.18 and, taking into account the ratio of the volumes of stored gas, under normal conditions, we will have about 2, in case of the same volume brought under normal conditions, in case of high pressure gas storage, using the expander, it will be 7,.18 / 2 = 3, 59 times more energy resources.

These are the general technical and economic indicators. The average cost of gas storage is 9,768 AMD/m^3, when we have a pressure of 12.5 MPa and the detonator-generator is used. When the final pressure is 6.3 MPa, the average cost of gas storage is 9,288 AMD/m^3 or decreases by 5.2%. This means that gas storage is the most appropriate option when using a pressure of 6.3 MPa, electric motor and detonator/դետանդերի. This was proved by comparing energy and economic indicators.

References

1. Klimenko V.S. Thermophysics and Aeromechanics, 2018, **4,** 613–622
2. Petrosyan A.L. National University of Architecture and Construction, Sci. work Bulletin, **III (70),** 2018, pp. 75 - 86.
3. Petrosyan A.L, Manukyan A.H. Armenia, Yerevan, Bulletin of the National University of Architecture and Construction (NCAA), **3 (56)** / 2017, pp. 57… 65,
4. V. Y. Demchuk, M. S. Doronin. Gas distribution systems: opportunities to improve energy efficiency. Research Center JSC "Giproniigaz"
5. E.B. Bukhgalter, B.O. Budnikov, N.V. Mojarova, S.A. Kulachkova. Tightness of natural gas underground storage facilities according to soil and environmental monitoring data.
6. Mozharova N. V., Kulachkova S.A., Journal of Soils and Sediments. **8-6,** 2008, pp. 434-432.
7. Vovk B.V., Arevfyev P.P. Oil and gas terminal, Collection of scientific papers. Tyumen, 2019, p. 75 ... 78.
8. Zemenkova, M. Yu. Methods of reducing technological and environmental risks in the transport and storage of hydrocarbons. Tyumen: TIU, 2018.
9. O.S. Radchenko, S. Yu. Podorozhnikov, E. V. Ogudova, Oil and Gas Terminal **13:** 2017, pp. 187-190
10. V. B. Kuntysh, N. M. Kuznetsov, St. Petersburg: Energoatomizdat. St. Petersburg. department, 1992.
11. A. N. Sleepless [et al.]; Fundamentals of calculation and design of heat exchangers for air cooling: reference book. St. Petersburg, Nedra, 1996.
12. Komova A.F. Oil and Gas Terminal **16,** 2019, pp. 151 ... 155.
13. A.G. Vertesov, A.S. Losatin. Gas industry. 2012. **3(674).** 59-62.
14. A. F. Kalininko, V. V. Kechatov, A. Yu. Toporov, Proceedings of the Gubkin Russian State University of Oil and Gas. 2009. **4.** 85-95.
15. V. Reznik, Kaliningrad Underground Gas Storage Administration: Results of gas injection into the Kaliningradskoye UGS facility in 2014, gas balance, measures to prepare for gas extraction and gas withdrawal regimes from UGS facilities in the autumn-winter period of 2014/2015
16. AnanichYu.P., Results of gas injection into the Mozyr UGS facility in 2014, gas balance, measures to prepare for extraction and gas withdrawal regimes from UGS facilities in the autumn-winter period of 2014/2015.
17. Expansion of the Kaliningrad UGS facility, January 2019 https:// www.interfax.ru/ business/645332,
18. Petrosyan AL, GrigoryanA.Kh., Architect. National University of Armenia, Bulletin, 2015, **4(4/48),** pp. 50… 59.
19. Electratherm Power + with BITZER HS.85 expander.
20. Internet site of OJSC "Ural Compressor Plant". "Expander-generator sets of gas distribution networks", 2016.
21. www.pkm.ru, 2019. OJSC "Penzkompressormash", compressor plants and stations on small and medium bases
22. "JSC Sumy Machine Building Plant", Compressor plants and stations, www.smz.ru 2018