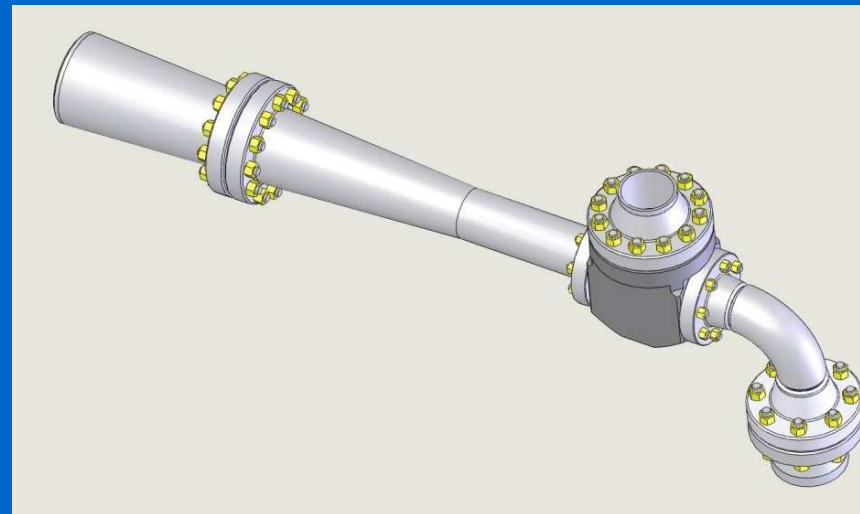
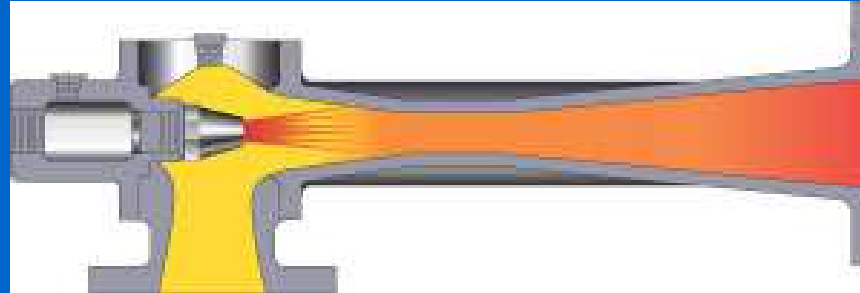


Ejection technologies for UGS

Authors: Bebeshko I.G.

Ejecting is a propulsion of low-energy flow of gas or liquid by means of media pumping down, which is driven by the other higher-speed working flow. Flow moving under a head creates negative pressure and is referred to as ejecting (active) flow, and the driven flow is ejected (passive) flow. As a result of mixing, the passive flow obtains the energy of the active flow, it is followed by equalizing pressure, flows' velocities and temperature.

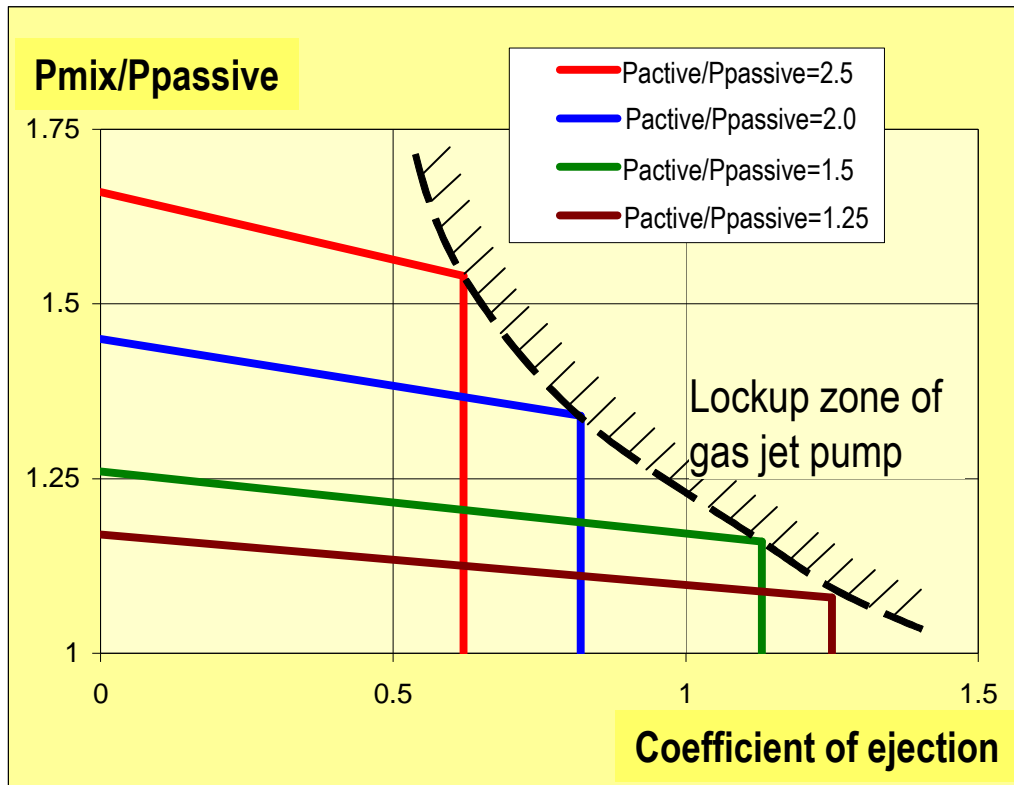




➤ Gas jet pump can be mounted both indoors and outdoors taking into account an easy approach for maintenance.

➤ Gas jet pump doesn't require the autonomous protective measures against weather effects and electromagnetic fields.

➤ Feeding lines of gas jet pump are equipped with the measuring and control valves at the high-pressure and low-pressure gas inlets and mixture outlet lines.

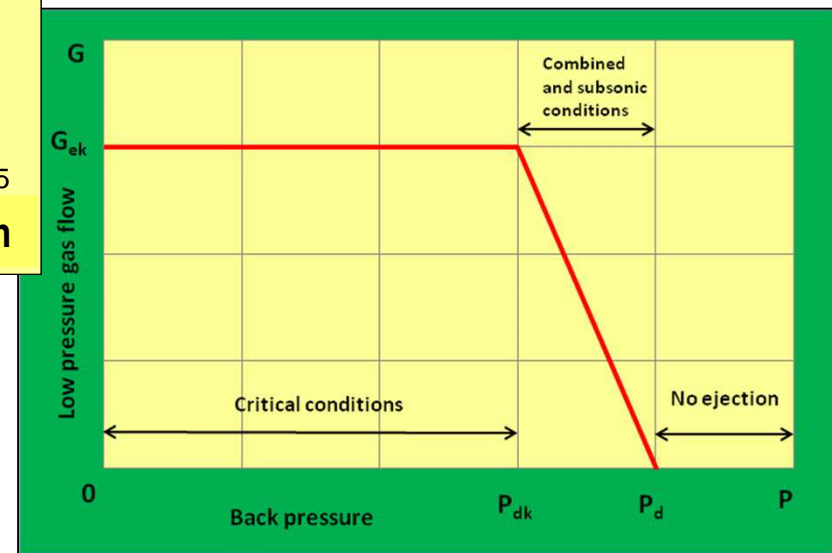


P_{mix} is a pressure of gas mixture at the gas jet pump outlet;

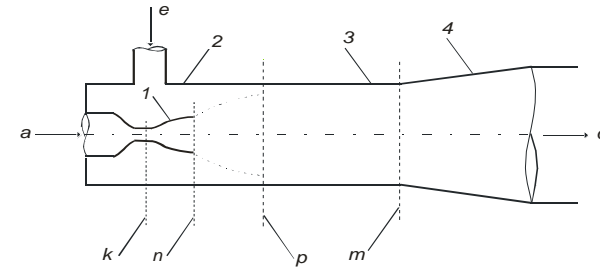
$P_{passive}$ is a pressure of passive (low-pressure) gas flow at gas jet pump inlet;

P_{active} is a pressure of active (high-pressure) gas flow at gas jet pump inlet;

Coefficient of ejection is a ratio of volume flow rate (bulk flow) of passive gas flow to volume flow rate (bulk flow) of active gas flow in gas jet pump.

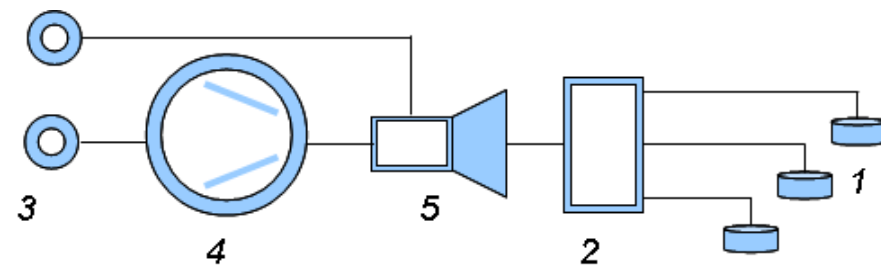


- Engineering algebraic model for bulk parametric analysis
- Imperfect (real) gas equation
- Nonstationary axisymmetrical Navier-Stokes equations
- Account of gas flow in gas jet pump interaction with the gas flows in the adjacent equipment (pressure blower, reservoir bed, junction line)

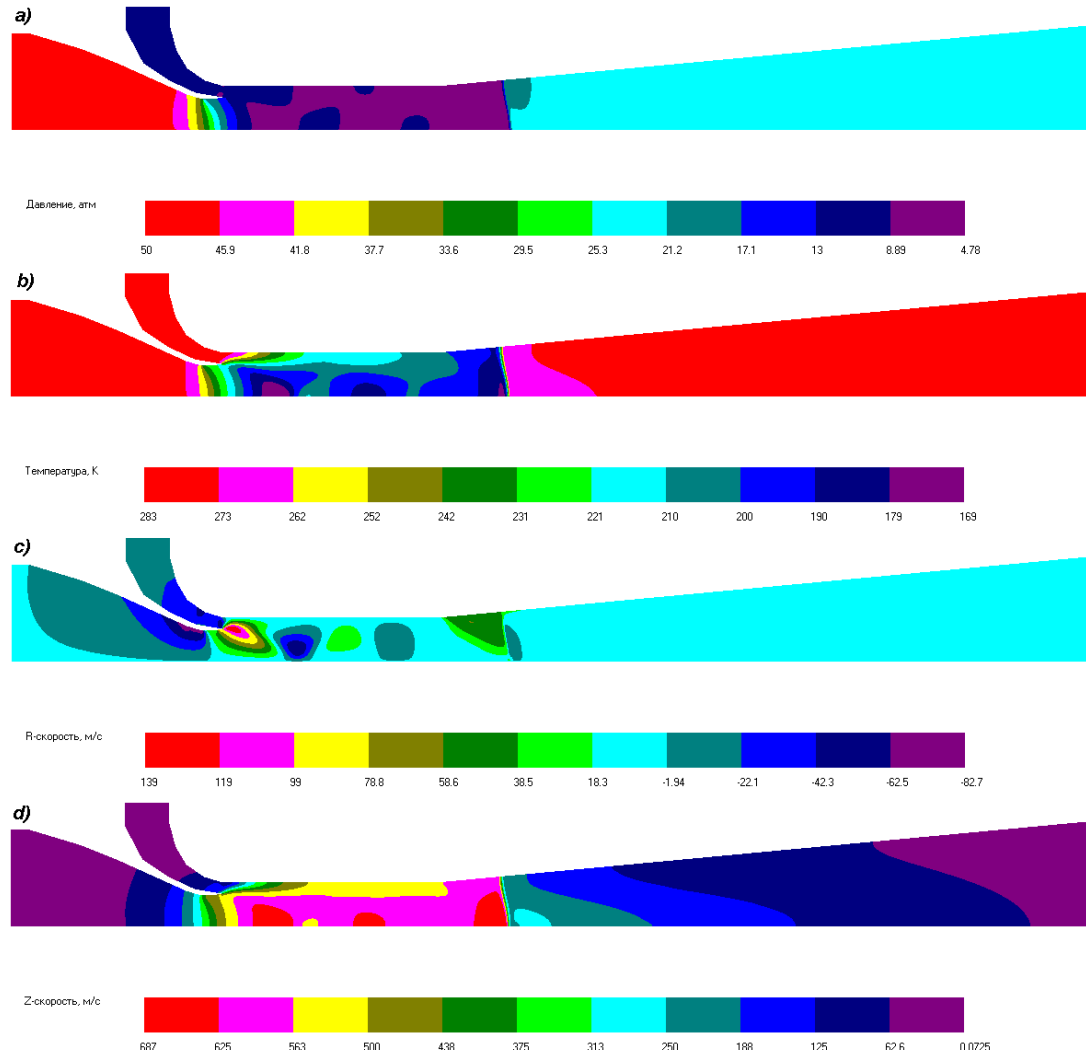


$$P = \frac{R_g \cdot T \cdot \rho}{1 - \bar{b} \rho} - \frac{\bar{a} \rho^2}{T^{1/2} (1 + \bar{b} \rho)}$$

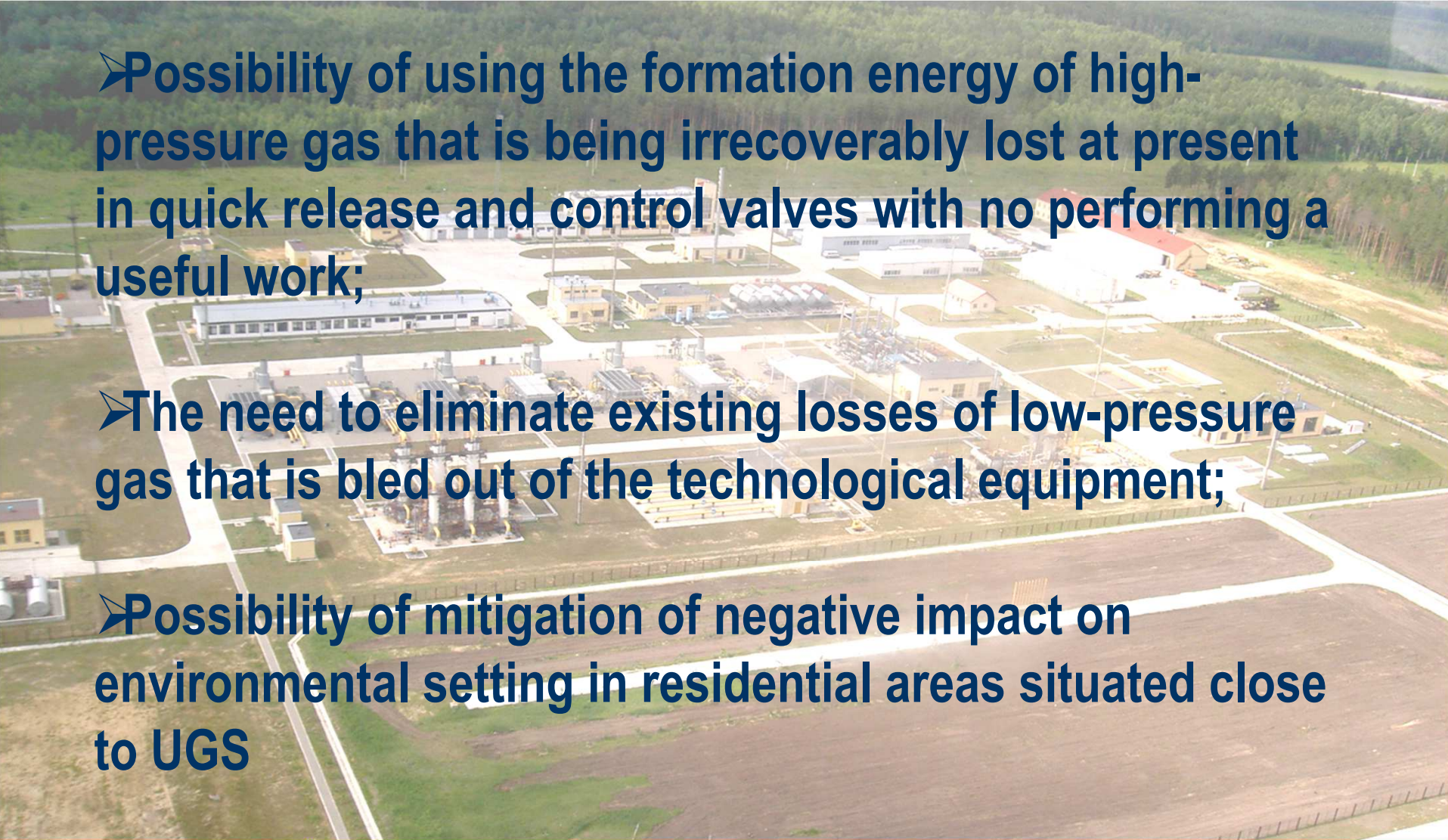
$$\frac{\partial(rU)}{\partial t} + \frac{\partial(rF)}{\partial r} + \frac{\partial(rG)}{\partial z} = \vec{H} + \frac{\partial(rQ)}{\partial r} + \frac{\partial(rR)}{\partial z}$$



1 – cavern; 2 – node; 3 – trunk gas pipeline; 4 – compressor; 5 – ejector



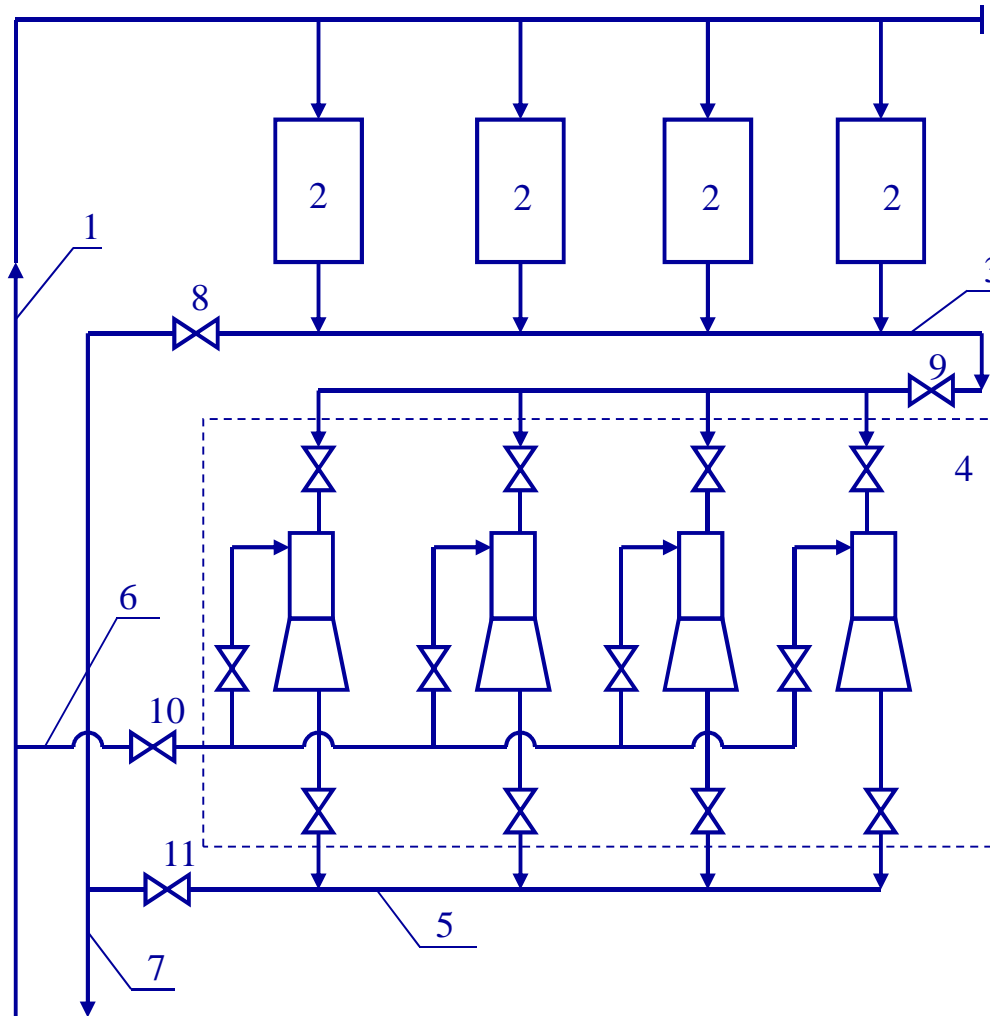
The use of ejection technologies in UGS system is conditional on the following:

- 
- An aerial photograph of a large industrial gas processing plant. The facility includes several large white storage tanks, various buildings, and complex piping systems. The plant is situated in a rural area with green fields and trees in the background.
- Possibility of using the formation energy of high-pressure gas that is being irrecoverably lost at present in quick release and control valves with no performing a useful work;
 - The need to eliminate existing losses of low-pressure gas that is bled out of the technological equipment;
 - Possibility of mitigation of negative impact on environmental setting in residential areas situated close to UGS

Gas ejector are used in UGS system with the following purpose:

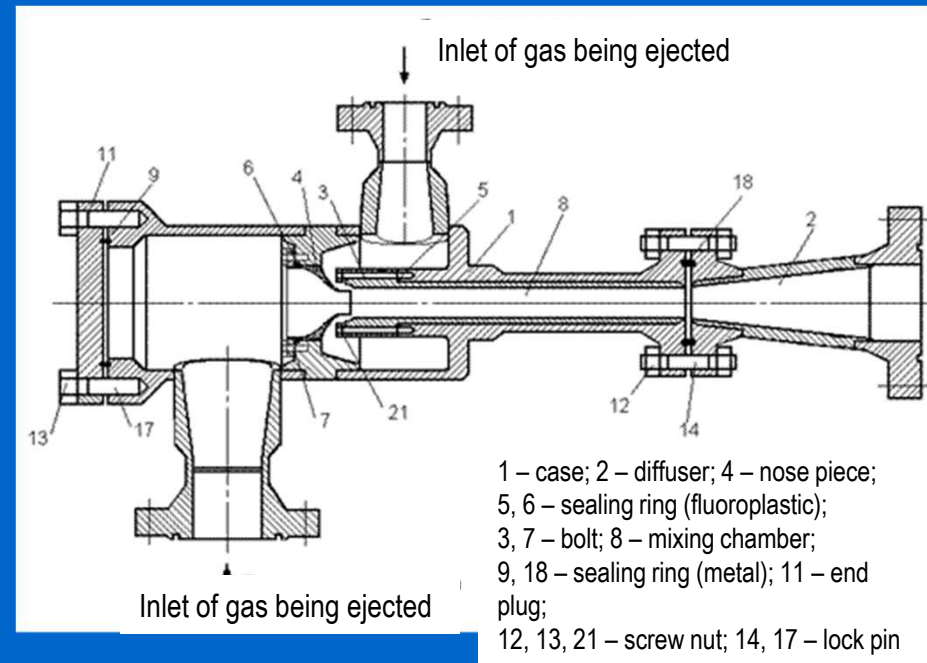
- Reducing energy consumption and hazardous emissions in joint operation of gas pumping units and gas jet pumps in the initial stage of gas injection;
- Capacity control of gas injection in the initial stage when the uncontrollable electrical gas pumping units are working in compressor department of UGS station;
- Deloading the loop of gas pumping units and gas pipeline system;
- Enhanced gas recovery from the storage in presence of high-pressure gas sources;
- Increase in performance of individual low-pressure wells by reducing the backpressure;
- Gas withdrawal from man-made deposits;
- Recovery of products of gas combustion in the boiler stacks, igneous vaporizers, etc.

Process scheme of simultaneous gas compression and ejection during injection to the storage



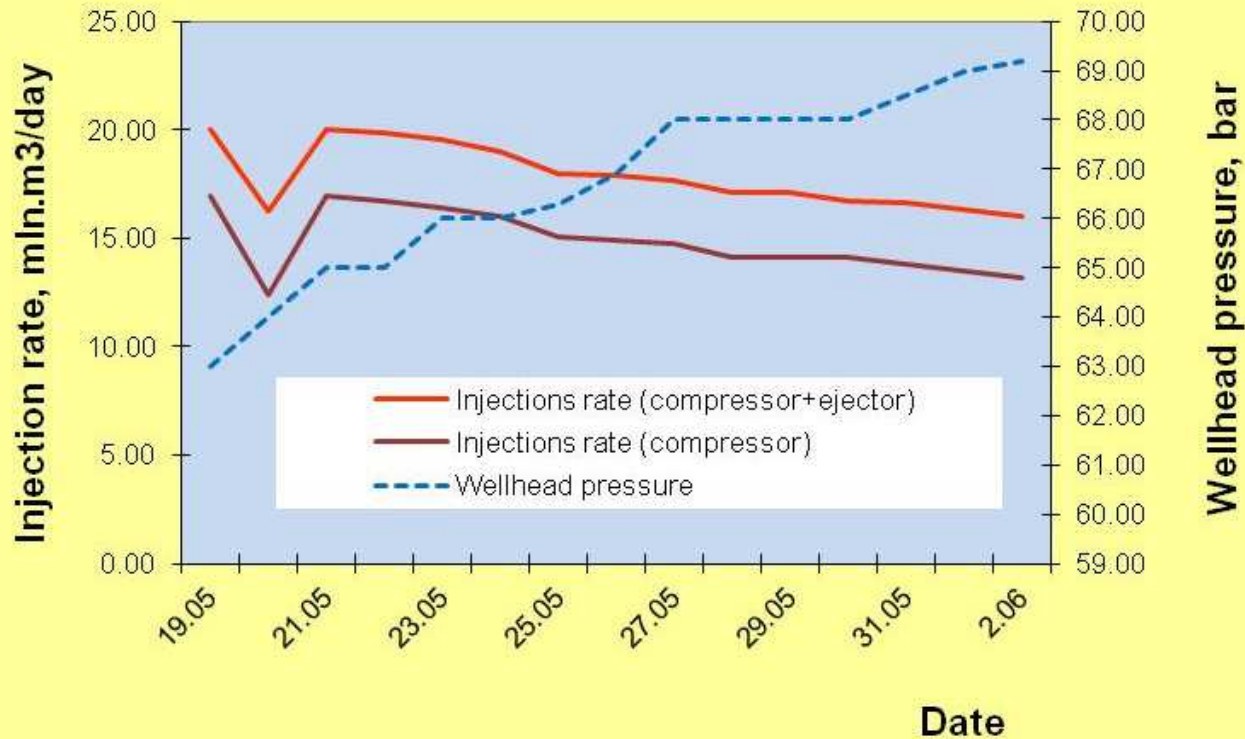
- 1-Всасывающий коллектор компрессорного цеха
- 2-ГПА
- 3-Выкидной коллектор компрессорного цеха
- 4-Блок эжекторов
- 5-Коллектор подачи смешанного потока газа
- 6-Коллектор подачи эжектируемого потока газа на блок эжекторов
- 7-Нагнетательный газопровод газохранилища
- 8-Отсекающий кран выкидного коллектора компрессорного цеха
- 9,10,11-Запорная арматура для стравливания газа с блока эжекторов

The implementation of the technology at the Peschano-Umetskoye UGS increased the daily injection rate by 27,3% and reduced specific electric power consumption by 11%.

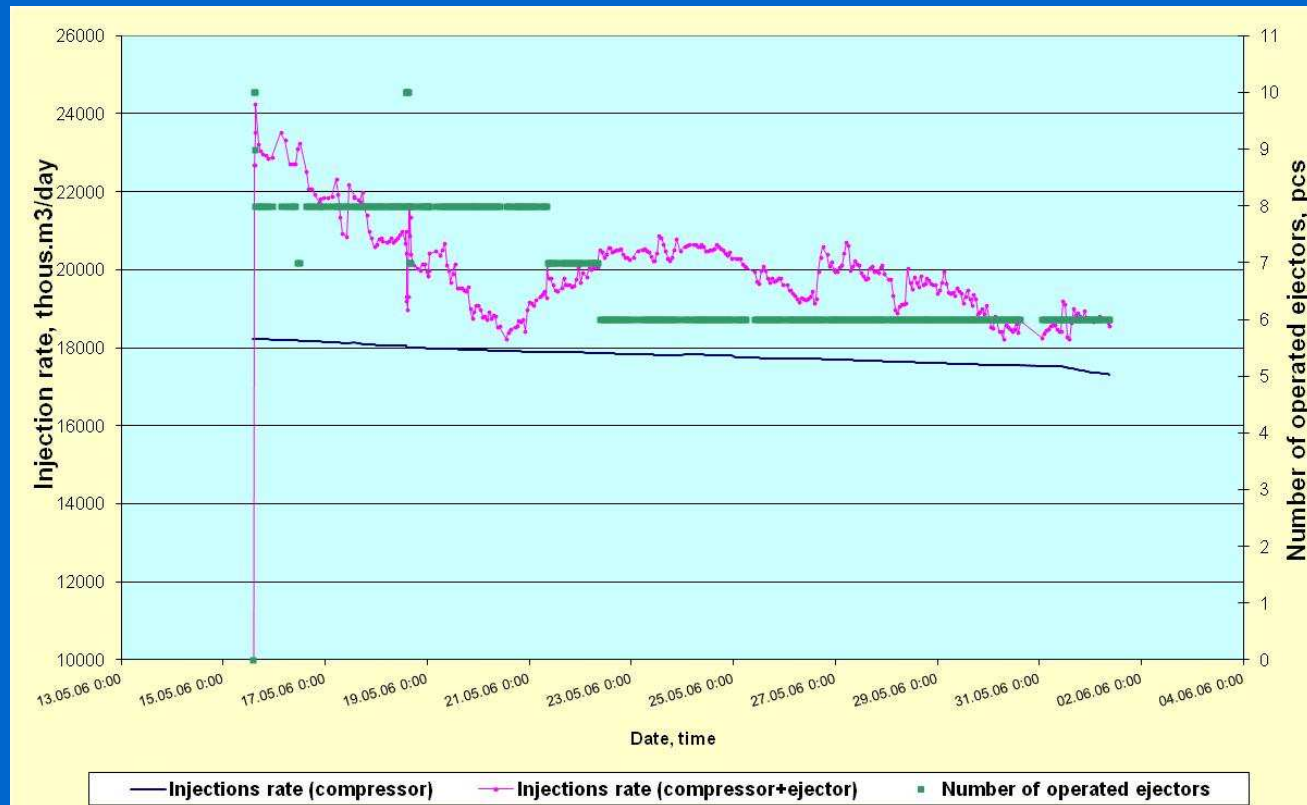


Gas ejector design was developed and patented in VNIIGAZ. Electors were manufactured at Voronezh Mechanical Plant.

Technology allows to increase the compressor gas injection rate above the total power of gas pumping units



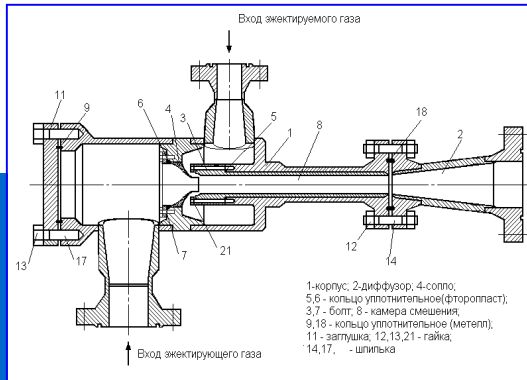
Technology allows to Regulate the injection rate



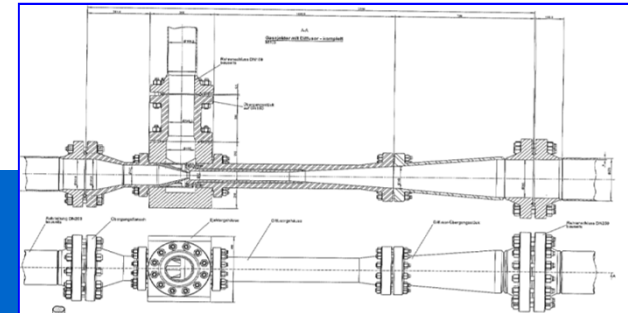
Introduction was done under scientific and technical cooperation program between JSC Gazprom and Verbundnetz Gas AG



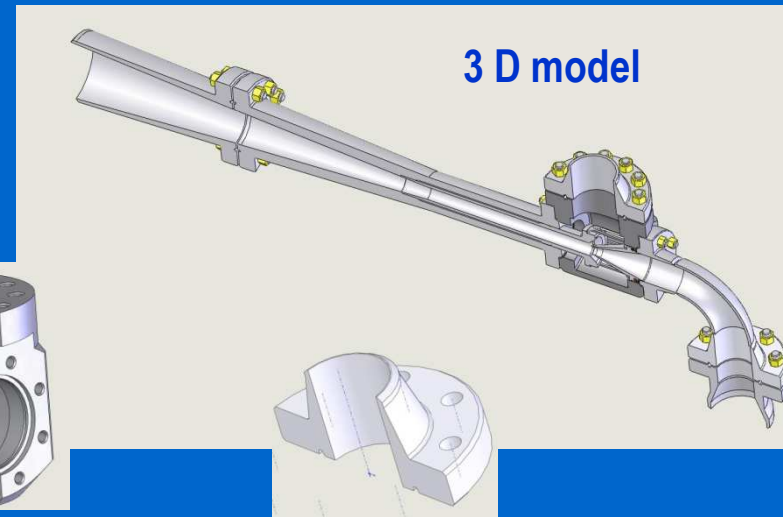
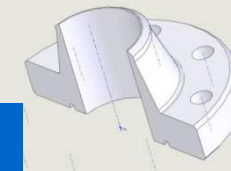
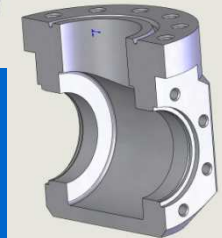
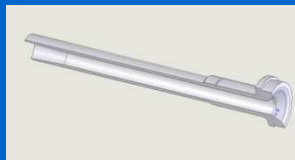
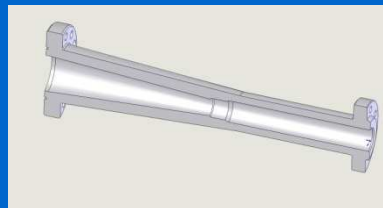
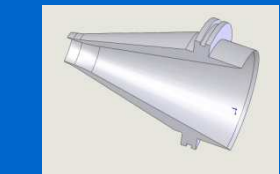
1. Process scheme of simultaneous gas compression and ejection during injection to the storage
2. Calculation of gas dynamic interaction of gas pumping units, ejector unit and branched system of field pipelines
3. Engineering and technical design of the ejector unit integration into existing surface UGS facilities
4. Development of the technical documentation and manufacture of the ejector unit



First version



Final version



3 D model





Gazprom VNIIGAZ LLC has a long-term experience in development and adaptation of gas jet pumping units in the context of various technological processes

Types of work:

➤ **Assessment of gas jet pumping units feasibility for various technological processes**

➤ **Prediction of gas-dynamic behaviour of gas jet pumping units**

➤ **Scientific and engineering support of design documentation development and manufacturing of gas jet pumping units**

➤ **Pilot testing of gas jet pumping units**