BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LXII No. 4A/2010	93 - 98	Seria Tehnică

Technical and Economical Issues Concerning the Possibility of Recovery of the Gas from Pipelines

Ion Pană

Universitatea Petrol - Gaze din Ploieşti, Bd. Bucureşti, nr: 39, Ploieşti
e-mail: ion.pana@upg-ploiesti.ro

Abstract

On the gas transmission pipelines from National Transport System occur frequently, incidents or works involving the repairing / changing of pipeline components. To intervene in this area have to empty the pipe in the atmosphere, losing a pretty significant amount of gas. A solution that can become profitable under certain conditions is the recovery of the gas by means of a mobile installation with compressor. The article presents some ideas about: the achieving of such installation; the calculus of time of evacuation and economical aspects concerning the feasibility of the project.

Key words: *natural gas, recovery, screw compressor*

Introduction

In Romania gas transmission capacity is provided by 13,110 km of pipelines and gas supply connections, with diameters between 50 mm and 1200 mm, at pressures between 0.6 MPa and 3.5 MPa and for international transit 5.4 MPa. Compression capability is provided by six gas compressor stations, located on the main transmission lines that have an installed capacity of 47,800 kW, with an annual capacity of 5.5 billion m^3 compression normal gas [14]. All these components of the National Transmission System ensure acquisition of natural gas producers / suppliers and transportation to customers / distributors or storage facilities.

Incidents involving cracking occur frequently (geometry defects, corrosion, third party intervention, natural phenomena, etc.) on the natural gas pipelines from National Transmission System [7, 10, 12]. Currently to act on the pipe, it empties into the atmosphere, losing a pretty significant amount of gas. Also, on the natural gas pipelines occur interventions (which can lead to loss of natural gas) required for various reasons: the cutting and inserting a pipe fitting to supply new customers, removing the cleaning / determination of defects devices (pigs) that have blocked the pipe, carrying a body orifice with the purpose of the execution of a connection pipe, coupling together two pipes through an adapter [5, 6, 8].

We note that the discharge of natural gas in the atmosphere is pollutant, although there are opinions that support the reduced character of this effect [1]. Methane, with a lower density than air, rises into the upper layers of the atmosphere, which interact, particularly ozone, oxidizing chemically active. Emissions of methane in the atmosphere are responsible for reducing ozone permeated the air. It is estimated that natural gas accounts for 25-42% of methane emissions resulting from fossil fuels or up to 12% of total emissions related to human activities [8, 10, 11].

Gas recovery from the pipe, with a mobile facility, is a solution that can become profitable under certain conditions. The article presents some ideas about achieving such facilities, with relationships that allow assessing the feasibility of such project.

Technical Solution Adopted

Pipe sections are separated by means of sectioning valves located at distances varying between 8 and 32 km. At the ends of pipeline sections are mounted on pressure dischargers (mounted devices with buried gas pipelines to discharge gas from a section of pipe), when they require the decommissioning of repair, pressure tests, coupling or cleansing. One of mounting schemes is given in Fig. 1 [7]. To empty the pipeline, it can be used two compressors (recommended screw type) mounted on a truck, coupled in parallel or in series depending on compression ratio. Using a single compressor is not compatible with our application: emptying the pipeline from 24 to 1.5 bar. Using screw compressor to transfer the gas from the damaged pipeline / pipeline subject to intervention to the pipeline used as a reservoir, are justified by the benefits afforded by this type of compressor: simple design, lack of valves, high compression reports, lack of mechanical contact between the elements gas compression, small gauge at the same parameters compared with gas piston compressors, high efficiency compared to turbo compressors, no dead space, easier control [2, 4, 9].

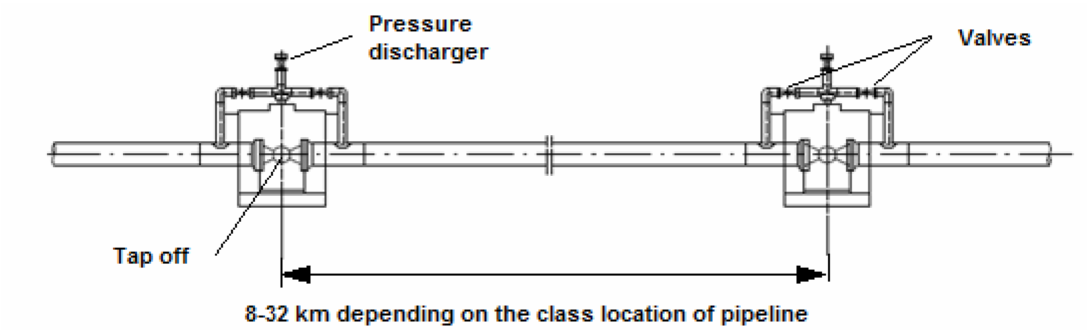


Fig. 1. Mounting of the pressure discharger on a detour between two manually operated valves.

Compressor drive motor can be realized with piston engine or gas turbine. It prefers a compressor drive turbine, because transfer costs remain on this energy source available to the transmission system operator. Connecting sections of pipe can be made through flexible pipes, as in Fig. 2.

Feasibility of the Project

To see if the project is effectively recovered are calculated: the price of gas recovered and the initial investment for the project. Pipeline segment volume V is:

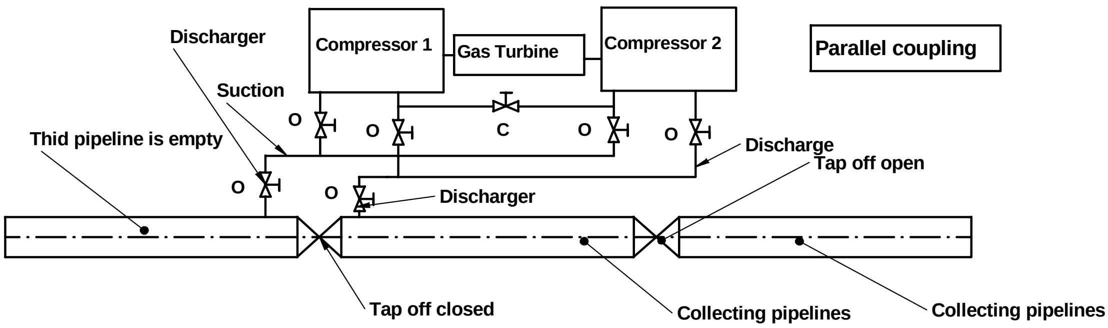
$$V = L \cdot \pi \cdot D^2/4\,; \qquad (1)$$

where L is the length of pipe, D – diameter of the pipe. Density of gas from pipeline ρ is:

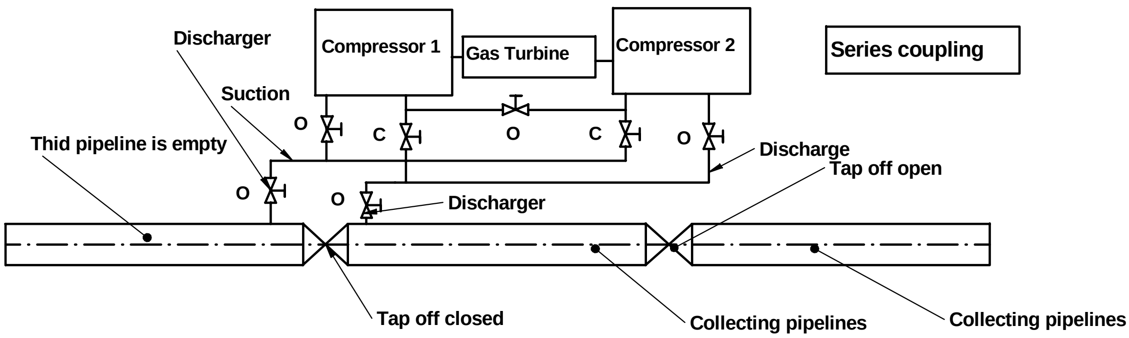
$$\rho = \frac{p}{ZRT}\,; \qquad (2)$$

where p is pressure of gas from pipeline, Z – deviation factor from the ideal gas law, R – constant of gas, T – absolute temperature of the gas from pipeline. Price Pt for gas is:

$$Pt = \frac{V\rho}{\rho_N c_{mc}}\quad; \qquad (3)$$



a



b

Fig. 2. Recovery of gas pipeline with two screw compressors: a) parallel coupling (law compression ratio); b) series coupling (high compression ratio).

where ρ_N is the density of gas in normal conditions, C_{mc} – price of m^3 gas under normal conditions. Power P required for the compressor is for a compressor stage:

$$P = \frac{n}{n-1} Q_N p_N \left(\varepsilon^{\frac{n-1}{n}} - 1 \right) \tag{4}$$

where n is the politropic exponent; Q_N – gas flow under normal conditions; p_N – normal pressure, 101.325 kPa; ε – compression ratio. Total compressor power P_t will be:

$$P_t = P \cdot n_t / \eta \tag{5}$$

where n_t is the number of stages to the compressor, η - the overall efficiency of the compressor. The volume of gas in the pipeline in normal conditions is:

$$V_N = V \frac{\rho}{\rho_N} \tag{6}$$

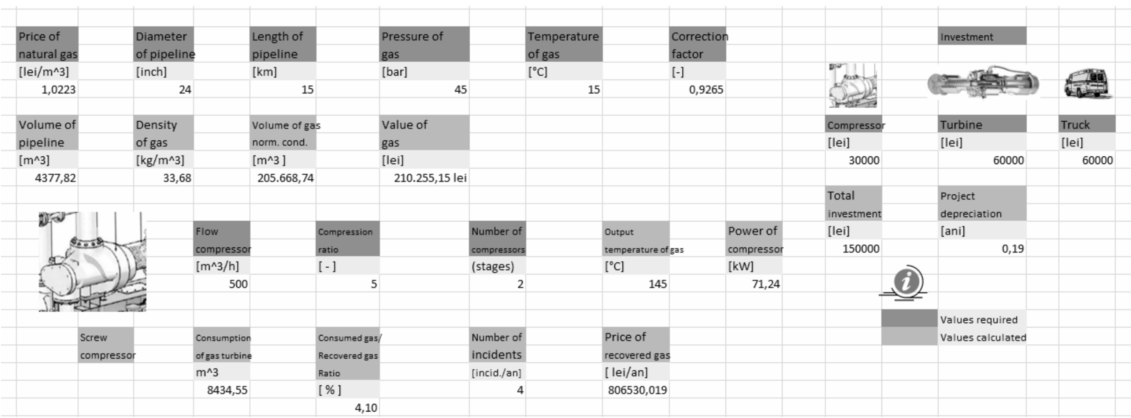


Fig.3. Graphical user interface done in Excel for the assessment of feasibility of the project.

The necessary energy to drive the compressor while draining the pipeline E is:

$$E = P_t \frac{V_N}{Q_N} e \quad , \tag{7}$$

where e is the energy required to obtain a kWh to the operating compressor motor (opposite the engine efficiency). Mass of the gas necessary to drive the gas turbine m_g is:

$$m_g = \frac{E}{q} \ , \tag{8}$$

where q is the energy from the combustion of one kilogram of gas used to drive the turbine. An indicator of profitability of the project is f_r the mass of gas consumed to drive the gas turbine by mass of the gas recovered:

$$f_r = \frac{m_g}{V_N \cdot \rho_N} \ , \tag{9}$$

obviously this report should be as small as 10% recommended. The investment required for the project is:

The Initial Investment Cost = Price of Compressor + Price of Engine (gas engine piston / turbine) + Price of the Truck (for transport) (10)

It is important to know how many incidents are on average per year, according to statistics available in Romania this figure is between five and six incidents per year (we refer here only to accidents and no technological change). Return on investment will be made in a number of years:

Investment Recovery = Initial Investment / Value of Recovered Gas (11)

Previous calculations are expressed in graphical user interface of Fig. 3, implemented in Excel.

Draining Time of the Pipeline

Time of emptying of the pipe is the most important parameter of the application because the worst situation comes to a pipeline that was damaged, gas escaping uncontrollable from it. There are several solutions of draining with volumetric compressors (piston, screw or lobes) mounted in parallel or in series (for low respectively large compression reports), or centrifugal compressors and volumetric compressors (for low respectively large compression reports). These solutions must be studied carefully with the transmission system configuration. An example of this analysis to the case of a discharge facility equipped with two screw compressors, powered by a gas turbine is given in Fig. 4. The emptying is done in two steps: coupling in parallel and then the series (with graphics in Fig. 1 obtained by numerical simulation). The conclusions for this situation (the imposed condition is that the installed power can provide compression ratio while maintaining the flow) are:

- with two screw compressors mounted in parallel is empty 80 % of the initial volume of gas;
- time of emptying for this phase is 7.5 hours;
- with two screw compressors mounted in series is empty 20 % of the initial volume of gas, time of emptying 4 hours;
- the final pressure in the pipeline is 1.2 bar, so we can recover all quantity of gas.

Conclusions

Regarding the possibility of using a mobile facility for transferring gas from the pipe subject to intervention in another pipe, can make the following observations:

- idea of using a plant with screw compressor is the best, it is simple, small outline, no dead space, with a high compression ratio;
- one positive aspect is less consumption of gas transfer, according to calculations of the author is between 4-6 % of the recovered gas;
- investment can quickly pay back in 1-2 years (according to calculations made by the author) the most common diameter of the pipeline transport system (24 inches) on average system pressure of 2.5 MPa, a good time for payback would be up to five years, if not satisfied this condition, the project does not deserve to be made [13].

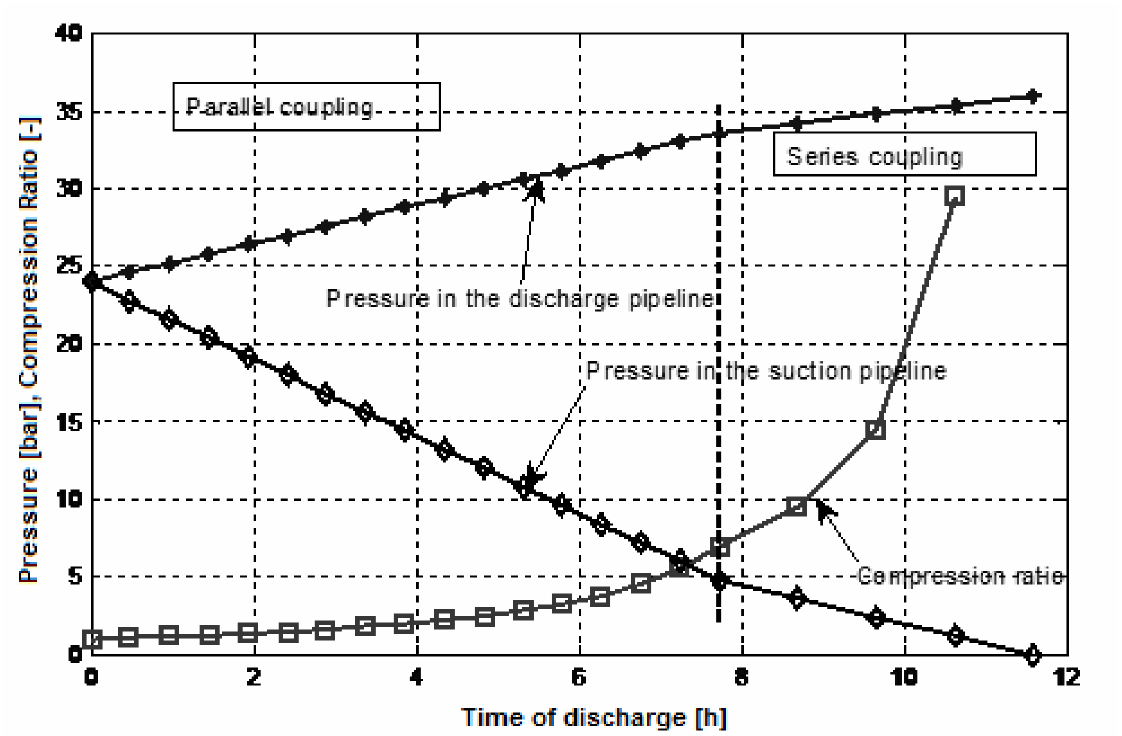


Fig.4. The results of simulation used to establish the time of emptying of the pipeline.

References

1. Arnold, K., Stewart M., *Design of Gas-Handling Systems and Facilities* (2nd Ed.). (Surface Production Operations; vol. 2). Boston, MA: Butterworth-Heinemann, an imprint of Elsevier Science Originally published by Gulf Publishing Company, Houston, TX, 1999.
2. Bloch, Heinz P., Hoefner John J., *Reciprocating Compressors - Operation and Maintenance*. Boston, MA: Gulf Professional Publishing, an imprint of Butterworth-Heinemann, Houston, TX, 1996.
3. Boyce, Meherwan P., *Gas Turbine Engineering Handbook* (2nd Ed.). Boston, MA: Gulf Professional Publishing, an imprint of Butterworth-Heinemann, 2001.
4. Brown, Royce N., *Compressors - Selection and Sizing* (2nd Ed.). Boston, MA: Gulf Professional Publishing, Houston, TX, an imprint of Butterworth-Heinemann, 1997.
5. Burgherr P., Hirschberg S., *Comparative Assessment of Natural Gas Accident Risks*, Paul Scherrer Institut – PSI, January, 2005.

6. Burns, Thomas E., *Serious Incident Prevention - How to Achieve and Sustain Accident-Free Operations in Your Plant or Company* (2nd Ed.). Boston, MA: Gulf Professional Publishing, an imprint of Elsevier Science, 2002.
7. Fodor I., Gheorghe U., *Recuperarea gazelor naturale care se evacuează în atmosferă cu ocazia intervențiilor la conductele de transport gaze*. Forumul Regional al Energiei – Foren 2008, *S4-28-ro,* Neptun, 15-19 iunie 2008.
8. Hasegawa, H., ş.a., *An Analysis on European and U.S. Gas Industry Deregulation – From the Viewpoints of Market Liquidity and Transportation Services*, IEES, February, 2007.
9. Lyons, William C., *Standard Handbook of Petroleum and Natural Gas Engineering* (2 vols.). Boston, MA: Gulf Professional Publishing, an imprint of Butterworth-Heinemann, Houston, TX, Vol. 1-2, 1996.
10. Mobley, R. Keith., *Root Cause Failure Analysis.* (Plant Engineering Maintenance Series). Boston, MA: Newness, an imprint of Butterworth-Heinemann, a member of the Reed Elsevier group, 1999
11. Muhlbauer, W. Kent. *Pipeline Risk Management Manual - Ideas, Techniques, and Resources* (3rd Ed.). Boston, MA: Gulf Professional Publishing, an imprint of Elsevier Science, 2004.
12. Osage, D.A. and Prager, M., *Status and Unresolved Technical Issues of Fitness-For-Service Assessment Procedures for the Petroleum Industry*, ASME PVP-Vol. 359, American Society of Mechanical Engineers, New York, 1997, p. 117-128.
13. Popescu D., Pavel A., *Risc tehnic/tehnologic*. Editura Briliant, Bucureşti, 1998.
14. * * *, www.transgaz.ro. Site-ul societății Transgaz S.A. Mediaş, operatorul sistemului de transport, din Sistemul Național de Transport.

Aspecte tehnice şi economice referitoare la posibilitățile de recuperare a gazelor din conducte

Rezumat

Pe conductele de transport gaze naturale din Sistemul Național de Transport apar frecvent incidente sau intervenții implicând repararea / schimbarea unor elemente ale conductei. Petru a interveni în aceste zone se goleşte conducta în atmosferă, pierzându-se o cantitate semnificativă de gaze. O soluție care poate fi avantajoasă în anumite condiții este recuperarea gazelor cu ajutorul unei instalații mobile prevăzută cu compresor. Articolul prezintă câteva idei despre: alcătuirea unei astfel de instalații; calculul timpului de golire şi aspecte economice referitoare la fezabilitatea proiectului.