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Influence of change of gas transportation mode on the stress condition of gas pipeline

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Abstract
Currently, underloading of gas transport system of Ukraine is 42.4% and continues to grow. During the loss of pipeline efficiency, the modes of its operation are changed significantly: changing the pressure and temperature of the gas, gas flows are redistributed in the pipelines system, the number of working gas-compressor units and compressor stations is changed. These changes cause unsteadiness of the transport system. So, there is necessity for studying of the operation modes of

the gas transport system during underloading. The western area of transport system of Ukraine, through which more than half of gas intended for export passes, was selected as the object of study.

Key words: PIPELINE, SYSTEM, STRESS STATE, UNSTEADINESS, MATHEMATICAL MODEL

Since 2007 there was a reduction of volumes of gas transportation through the gas transmission system of Ukraine. In 2015 the volume of gas transit settled down up to 62.5 bln m^3. This means that the system is 2.5 times underloaded now. So it may be concluded that gas transmission system of Ukraine works underused [1]. Disuse of gas pipelines leads to change of working modes, change of amount of gas in the system and change of action of internal loadings.

For carrying out researches, western part of gas transmission system, which completely corresponds to a configuration of the general system, is chosen. The main function of western area of gas transmission system of Ukraine is the transit of natural gas to the countries of Western and Central Europe. This area consists of six compressor stations with superchargers of natural gas and linear areas between them. General design capacity of the chosen area of gas-transport system (GTS) is 111 billions m^3 per year [1]. Measurements of technological parameters at an entrance and an exit of each compressor plant (CP), and also parameters at entrance and exit are possible on the area. Regular devices of gas transmission companies were used for measurement. Critical parameters measured were pressure and a gas flow.

The scheme of an area is presented in the figure 1.

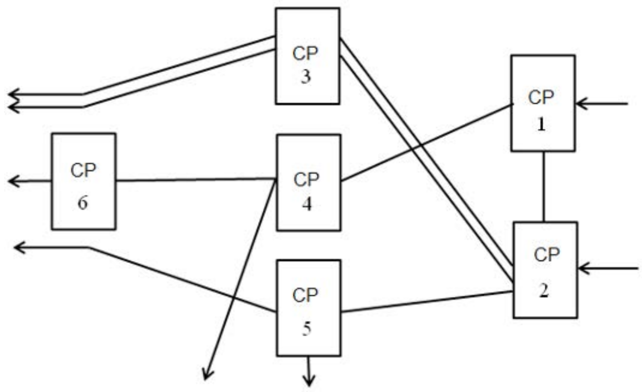

Figure 1. Gas pipeline site diagram

An experiment was conducted to reveal the nature of change of modes of area running regime of the gas pipeline during 2013 - 2014. Almost eight hundred modes of running regimes were analyzed [2,3].

First of all there was considered a gas rate by certain gas pipeline area. During considered period gas rate changed from 1035 thousands m^3/hour to 3556 thousands m^3/hour, or by 3.44 times. Change of a gas rate is presented in figure 2.

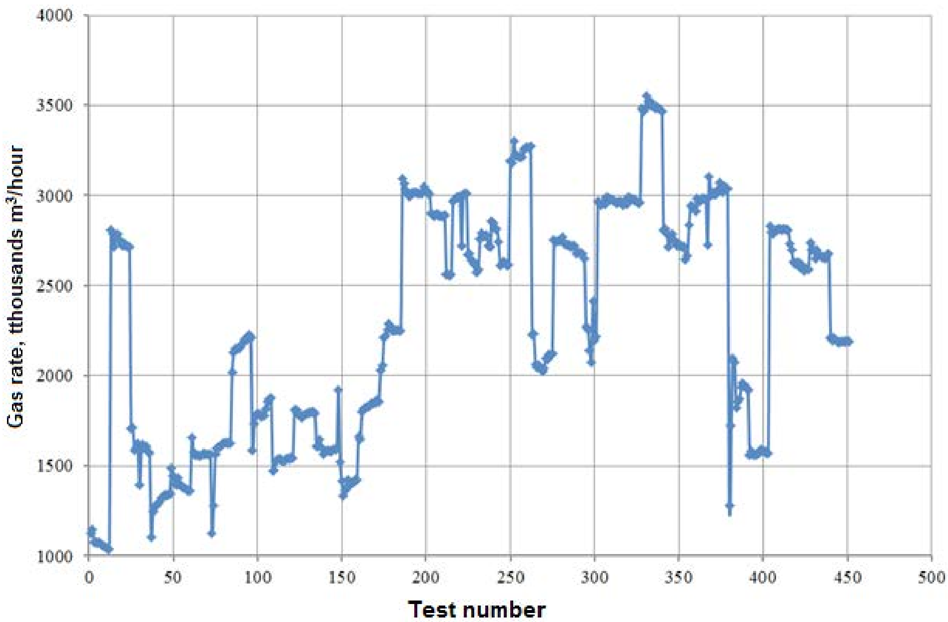

Figure 2. Gas rate by gas pipeline area

Change of gas consamption causes change of amount of gas in the pipeline. Avarege changes were used for an assessment of amount of gas. The mass of gas in one running meter of the gas pipeline was determined by dependence

$$M = \frac{\pi \cdot d^2}{4} \cdot \frac{P}{z \cdot R \cdot T},$$

where d - inner diameter of the gas pipeline,
P - absolute pressure in the gas pipeline,
z - coefficient of gas compressibility,
R - gas constant,
T - gas temperature in the gas pipeline.

The mass of gas is presented in one running meter of the gas pipeline in figure 3.

The mass of gas in one running meter of the gas pipeline changes from 59 kg up to 84 kg. With a span length of air transition through 35 m obstruction the mass of gas in span between supports is from 2065 kg to 2940 kg that will cause fluctuations of a pipe.

Important aspect of operation of gas pipelines is the behavior of offtakes during reverse of direction of a gas flow. Force affecting the obstacle at change of gas flow is determined by dependence [4]

$$F = (1 - cos\alpha) \cdot \rho \cdot Q_o \cdot V_o$$

where ρ – gas density, kg/m^3;
Q_o – gas consumption by the gas pipeline, m^3/s;
V_o – gas velocity on the pipeline, m/s.

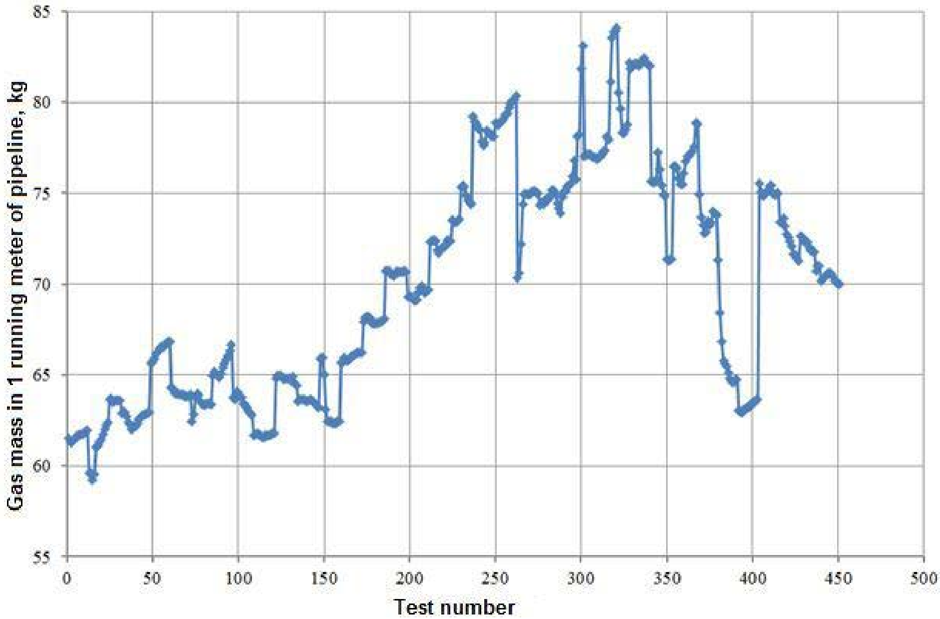

Figure 3. The size of force arising in pipeline bend 90° is presented in figure 3

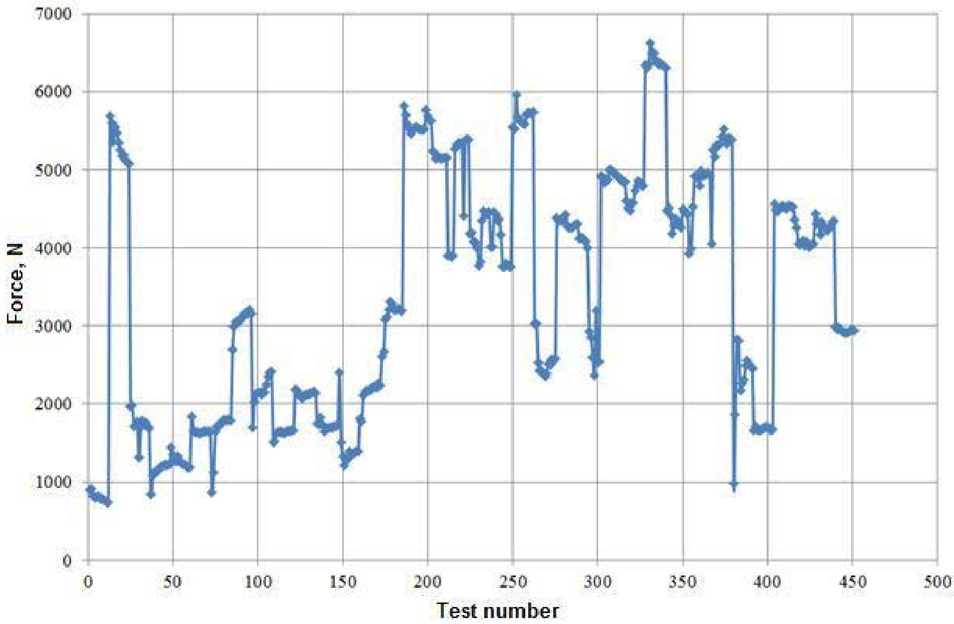

Figure 4. Force affecting the offtake at the quarter turn

Conclusions

During researches the best effort in the bend was 6625 N, and minimum – 744 N. Variation factor of effort is 162% that speaks for considerable heterogeneity of selection and also gas pipeline running regime. Change of force causes change of tension in a bend of the gas pipeline and therefore demands additional control.

Changes of internal pressure on pipe walls cause tension, which, concentrating in zones of the specified defects, that is in the local areas, that is more in the ragged areas, reach metal liquid limit and even exceed it.

When repeated-static loadings, irreversible processes of dynamic strain aging and gradual accumulation of damages (microplastic deformation), which lead to formation of microcracks, decrease in metal resistance to damages, takes place. At destruction of pipes metal, except the central microcrack there occur supplementary cracks, part of which merges with main crack.

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