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Influence of gas transport volumes reduction on gas pipeline stress state

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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

The gas transport system (GTS) of Ukraine is one of the world's largest gas transport systems. It performs two main functions: providing domestic consumers with natural gas, and also transit of natural gas along the territory of Ukraine to the countries of the Western and Central Europe. The gas transport system of Ukraine extension is more than 36 ths. km. It includes gas pipelines of diameter up to 1400 mm, interstrand crossings, compressor stations with different type of the drive, isolation valve etc. Extent of gas pipelines with a diameter more than 1020 mm is 14 ths. km. Capacity of the gas transport system at input is 288 bln m^3 per year, and at output is 178.5 bln m^3 per year, including the countries of Europe -142.5 bln m^3 per year. However, in 2011, transit of gas along the territory of Ukraine was 104.2 bln m^3 (lower than it was planned), but during 2013, it made only 83.7 bln m^3 or 58.7% to the countries of Europe. The transit of gas also tended to reduce along the territory of Ukraine in 2014, the volume of gas transit

decreased by 27.8% to 62.2 bln m^3 per year; that is 42.4% of the maximum loading. Till April 2015, the transit of gas was 5.2 bln m^3. So, it is possible to draw a conclusion that the gas transportation system of Ukraine operates with considerable underloading [1].

Underloading of gas pipelines leads to change of operating modes. Reduction of gas consumption leads to switching off of gas-compressor units (GCU) and compressor stations (CS), and operating GCU come to off-design operating modes. It increases fluctuations of a gas column in the gas pipeline. The pressure is characteristic of gas condition in the gas pipeline. Therefore, the course of gas-dynamic processes can be interfered by change of pressure in the gas pipeline. Gas pressure also has an impact on pipes metal stress, and nature of pressure change affects fatigue stresses in pipes.

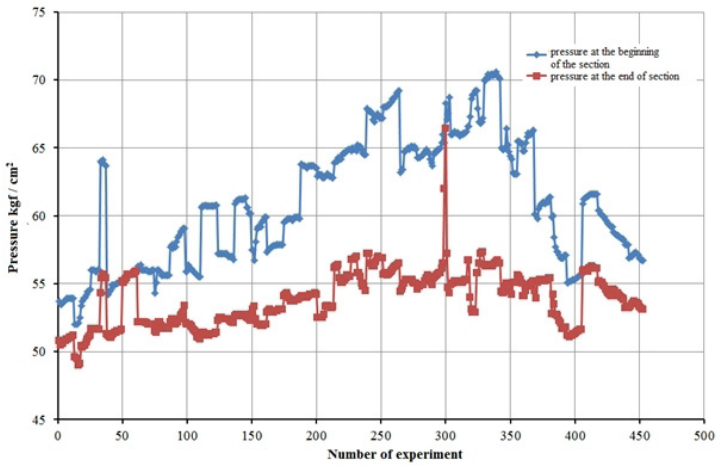

Figure 1. Pressure in the section of the gas pipeline during the research period

The experiment in the main gas pipelines "Urengoy-Pomary-Uzhgorod" and "Progress" in the section Bogorodchana - Volovets was conducted during 2013 - 2014 for determination of nature of pressure change [2]. The pressure was measured at the beginning and at the end of a section of the gas pipeline, and average pressure was calculated in a section. Change of pressure and stress in the specified gas pipelines within a year is presented in Figures 1 - 4. The amount of pressure fluctuations in unit of time and fluctuations amplitude were determined. The fluctuation frequency range of pressure is 20 1/h [3]. Thus, within a year 175200 fluctuations of pressure take place in the area of the gas pipeline.

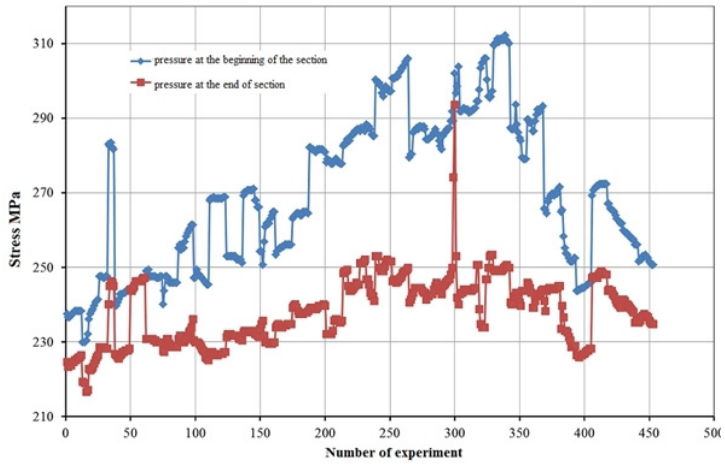

Figure 2. Stress in the "Progress" gas pipeline during the research period

In 2013, the maximum pressure of gas at the beginning of a section of the "Urengoy-Pomary-Uzhgorod" gas pipeline was 70.5 kgf/cm^2, the minimum pressure was 52 kgf/cm^2. Pressure at the end of a section of the gas pipeline was 67.2 kgf/cm^2 and 48.2 kgf/cm^2 respectively. So, the maximum change of pressure at the beginning of a section of "Urengoy-Pomary-Uzhgorod" gas pipeline was 18.5 kgf/cm^2, and at the end of a section was 19 kgf/cm^2. During this time, average pressure changed from 50.57 kgf/cm^2 to 67.35 kgf/cm^2.

In 2014, the maximum pressure of gas at the beginning of a section of the "Urengoy-Pomary-Uzhgorod" gas pipeline was 65.8 kgf/cm^2, the minimum pressure was 50.7 kgf/cm^2. Pressure at the end of a section of the gas pipeline was 61.1 kgf/cm^2 and 42.5 kgf/cm^2 respectively. The maximum change of pressure at the beginning of a section of "Urengoy-Pomary-Uzhgorod" gas pipeline was 15.1 kgf/cm^2, and at the end of a section was 18.6 kgf/cm^2. During this time, average pressure changed from 46.72 kgf/cm^2 to 62.82 kgf/cm^2.

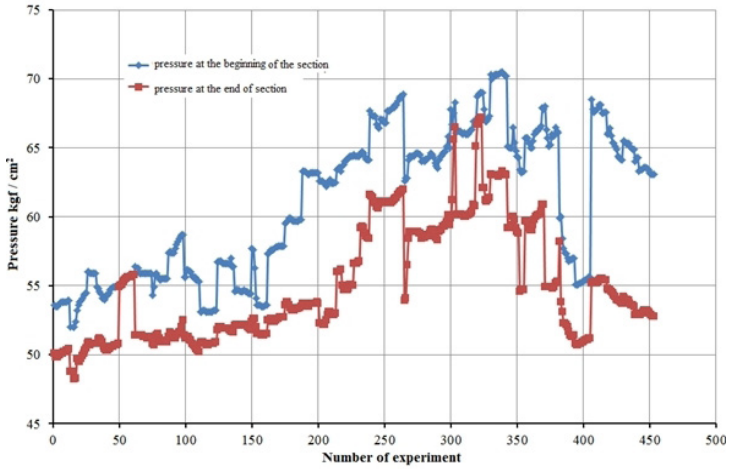

Figure 3. Pressure in the section of "Urengoy-Pomary-Uzhgorod" gas pipeline during the research period

In "Progress" gas pipeline during 2013, the maximum pressure of gas at the beginning of a section of the gas pipeline was 70.6 kgf/ cm^2, the minimum pressure was 70.6 kgf/cm^2. Pressure at the end of a section of the gas pipeline was 66.4 kgf/cm^2 and 49 kgf/cm^2 respectively. The maximum change of pressure at the beginning of a section of "Progress" gas pipeline was 18.6 kgf/cm^2, and at the end of a section was 17.4 kgf/cm^2. During this time, average pressure changed from 50.57 kgf/cm^2 to 67.35 kgf/cm^2.

In 2014, the maximum pressure of gas at the beginning of a section of this gas pipeline was 64.6 kgf/ cm^2, the minimum pressure was 50.8 kgf/cm^2. Pressure at the end of a section of the gas pipeline was 61.6 kgf/cm^2 and 42.9 kgf/cm^2 respectively. The maximum change of pressure at the beginning of a section of "Progress" gas pipeline was 13.8 kgf/ cm^2, and at the end of a section was 18.7 kgf/cm^2. During this time, average pressure changed from 46.96 kgf/cm^2 to 62.96 kgf/cm^2.

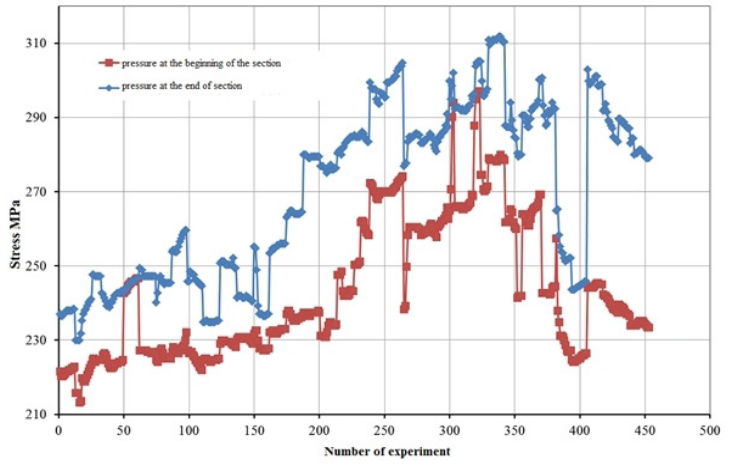

Figure 4. The stress in "Urengoy-Pomary-Uzhgorod" gas pipeline during the research period

Amplitude of pressure change at the beginning of section of "Urengoy-Pomary-Uzhgorod" gas pipeline in 2013 was up to 9.51 kgf/cm^2 or 16%, at the end of a section was 12.8 kgf/cm^2 or 26%. In 2014, amplitude of fluctuations at the beginning of a section was up to 8.3 kgf/cm^2 (14%), and at the end of a section was 10.6 kgf/cm^2 (20%).

Change of pressure in section of "Progress" gas pipeline in 2013 was 9.6 kgf/cm^2 (16%) at the beginning of a section, and 12 kgf/cm^2 (22%) at the end of

a section. In 2014, the same parameters were 9.0 kgf/cm^2 (17%) at the beginning of a section, and 9.6 kgf/cm^2 (19%) at the end of a section.

Thus, we can draw a conclusion that amplitude of fluctuations decreases with reduction of loading of the gas pipeline.

Besides, quantity of gas pipeline section operating modes, which amplitude of pressure fluctuations does not exceed 10%, is 86% for "Urengoy-Pomary-Uzhgorod" and "Progress" gas pipelines.

Conclusion

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 redistri- buted 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.

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