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Research on exploitation of gas pipelines at areas crossing the natural and artificial obstacles by the method of natural pulse of electromagnetic field of the Earth (NPEMFE)

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Abstract

On the basis of the performed complex of theoretical and experimental studies, the important scientific and technical problem on ensuring the trouble-free operation of main gas pipelines in mountain conditions was solved. By using the method of natural pulses of electromagnetic field of the Earth (NPEMFE), it was found that any interference in balance of the rock mass provoked the formation of centers of mechanical stresses, i.e. it was the stress concentrator and the source of future landslides occurrence under appropriate conditions. These stress concentrators include routes of main gas pipelines laid in the mountains. Operational control of the stress-strain state of the rocks on the pipeline route and repeated observations on the most dangerous sections allow us to monitor the dynamics of the stress field and predict the development of geological processes, as well as to build a scheme of object load.

Key words: STRESS CONCENTRATOR, WELDED JOINTS, WELD SEAM, PIPELINE, NATURAL PULSES OF ELECTROMAGNETIC FIELD OF THE EARTH (NPEMFE)

The gas transportation system (GTS) of Ukraine is an important factor of energy security of the state both in the economic and political planes. Ukraine has the world's largest transit gas flow from Russia to Europe. Therefore, special attention is paid to scientific researches for ensuring the reliability and durability of the GTS as an important component of the energy security of the state.

The great length of the gas transportation system and the complexity of the technological piping scheme determine the significant losses of gas during transportation and consumption. Therefore, the important operational problems are the calculation of gas and reduction of its losses during transportation and consumption.

The objects of gas transportation system are often placed in the geodynamic active zones of complex reliefs and under appropriate climatic conditions are exposed to mechanical loads from the rocks. Ultimately, this can lead to deformation and failure of pipes and other process structures. Especially dangerous are shifts in the mountainous area. Therefore, it is important to be able to predict the process of geodynamic activity of rocks in order to prevent emergency situations.

To identify stress state of rocks, various methods of physical researches are used. Among them the method of natural pulse of electromagnetic field of the Earth (NPEMFE) has dominant position.

On the slopes of the landslide, there are always favorable conditions for the occurrence of electromagnetic pulse emission processes [1-6]. The accumula-

tion of stress in the rocks to critical values and their relaxation, the development of micro- and macro-cracks, the phenomenon of electroadhesion, tribopolarization, dehydration, destruction of double electrical layers, phase transitions, friction result in the formation of pulsed electromagnetic fields of different intensity. The frequency range of electromagnetic pulses can be wide depending on the extent of the shift and geological conditions of its development.

Studies and observations of landslides indicate unequivocally that NPEMFE method can be effective for predicting the landslides. It points to a local increase of stress and strain, which is an important condition for the formation of shift. These processes are not fleeting in the initial stages of the formation conditions of the shift, which allows implementing the relevant engineering works and reducing the serious negative effects of the landslide. This is especially important for the dangerous objects such as the main gas pipelines (Fig. 1) and gas distribution networks of different pressures.

Figure 1. Scheme of gas pipelines passing through the natural and artificial obstacles

To study the effect of local deep stresses on changing the intensity of NPEMFE at different depths of the rock, the research on Bogorodchansky underground gas storage (UGS) and adjacent gas pipelines crossing natural and artificial obstacles was carried out. The study of these areas by the given geophysical method allowed us to obtain updated information on the distribution of zones of increased stress-strain state (SSS) of rocks and zones of stress relaxation to determine the boundaries of the territory with the development of deformation processes, as well as to define the spatial heterogeneity in the general field of mechanical stresses.

Field works were carried out to modify the mapping. The repeated measurements were performed to monitor the variations in the electromagnetic background. The step between measurements was 5 m for an exact establishment of the probable occurrence of anomalous phenomena in the soil mass.

Monitoring the distribution of stress field was carried out by two of devices of "Adonis-32M" types made especially for measuring the amount of electromagnetic pulses per time unit in a compact portable version with low power consumption.

The field data processing consisted in averaging of the measurements obtained at the point with the subtraction of the regional variations in the electromagnetic background. In the course of processing the complex of statistical methods of observations analysis was used to determine their accuracy in assessing the identified anomalies.

As the physical and geological model in the process of interpretation of field observations, we accept that the observed values of NPEMFE in each studied area are random. If the area is homogeneous in its geological structure, geophysical properties, the random values NPEMFE must belong to the same general totality and their deviations are random.

For uniformity characteristics of series measurements at one point and elimination of random deviations,

the null hypothesis was applied using parametric criteria and verification of samples on belonging to the normal distribution law.

The experiment was carried out at various filling of gas storage facilities and gas pipelines, i.e. with different internal pressures. The first measurements were carried out in June in minimally filled storage with internal gas pressure of 58 atmospheres. The second measurement was performed in the same picket lines in December in filled storage with internal gas pressure of 93 atmospheres.

From the foregoing, it follows that any intervention in the rock mass balance provokes the formation of centers of mechanical stresses, i.e. it is a stress concentrator and the source of future landslides occurrence under appropriate conditions. These stress concentrators are main gas pipeline routes laid in the mountains.

Conclusion

The methods and tools for the operational monitoring of the stress-strain state of the rocks on the gas pipeline routes were developed. The method of determining the permissible level of randomly oriented load on the pipeline in the area of the ground slipping was proposed.

The parametric methods of diagnosing the state of compressor stations, gas pipelines and equipment in non-stationary non-isothermal modes, which allow us to construct the actual characteristics of the objects of complex gas transportation systems were scientifically justified. On this basis, a method of operation modes selection with taking into account multi-criteria optimization was built. A strategy of optimal maintenance of objects of gas transportation system was developed according to the results of the parametric diagnosing the state.

The causes of gas losses in main pipelines and distribution networks were studied and systematized. Recommendations and normative documents for reducing the losses in transportation and distribution were developed and introduced in the gas distribution companies of Ukraine.

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