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RESEARCH OF THE MATHEMATICAL MODEL FOR THE EVALUATION OF EXTERNAL CORROSION PROCESSES ON OIL PIPELINES

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Abstract. *Oil pipelines are operated in a complex corrosive environment – soil, the conditions of which are characterized by heterogeneity and are determined by various factors. At the same time, the oil pipeline is affected not only by soil conditions, but also by other environmental factors: atmospheric air, mechanical load. All this indicates that oil pipelines, together with the environment, are complex systems and can be studied using mathematical modelling.*

Oil and gas industry facilities are of great importance for the state. In particular, oil pipelines are designed to transport fuel from refineries and pump it into railway tanks or fuel trucks in order to provide the country with fuel. These infrastructure facilities are of strategic importance for the energy security of Ukraine and the solution of military-strategic tasks. However, on the other hand, any violations of the tightness of these objects pose a danger to the ecological situation in the region and to nature.

Thus, the Poltava region in Ukraine has a fairly developed network of main oil pipelines, oil product pipelines and gas pipelines, the average life of which is 31 years, and the first constructed oil pipelines have been operating for more than 48 years [1, 2]. Long-term interaction of the pipe metal with the environment leads to the intensification of corrosion processes, degradation of the physical and mechanical properties of the pipe wall material. Possible defects in the manufacture of pipelines, intentional or accidental damage to their integrity, contribute to the onset and rapid development of corrosion processes [3]. In this regard, the risk of accident-dangerous defects increases, which negatively affects the environmental safety of their operation. Prevention of the formation of cracks on the surface of oil pipelines and oil leakage can be achieved by predicting corrosion activity, taking into account the factors characterizing corrosion processes on the metal. This ensures an increase in the environmental safety of the operation of strategic infrastructure facilities [4].

This issue is especially acute in relation to oil pipelines operated with sections where the pipeline insulation is broken in conditions of contact with electrolytic solutions. Such areas have a significant impact on the development of the pipeline corrosion, creating conditions for the emergence of macro-corrosion pairs. On underground pipelines with areas where the insulation is broken, the anodic and cathodic polarization characteristics of steel change significantly and, as a result, the steel potentials in these places. In view of the fact that the operation of an oil pipeline with sections where insulation is broken is associated with electrochemical corrosion of the pipeline metal, the main attention to ensure the environmental safety of pipeline operation should be given to determining the characteristics of the corrosion process on the pipeline in places where insulation is broken due to the operation of a corrosion element. The current of these galvanic couplers is a universal indicator for calculating metal losses in cracks.

In this formulation, the pipeline electrochemical corrosion problem is reduced to determining the stationary electric field that occurs during the operation of a galvanic couple on a heterogeneous electrode, that is, writing the equations and formulas of the boundary conditions that the potential of this field satisfies.

The main characteristic of the electric field is the potential, which can be used to find the density of the corrosion current according to the well-known Ohm's law in differential form

$$i = \gamma \frac{\partial \phi}{\partial N},$$

where γ – the electrical conductivity of the electrolytic medium; N – the normal to the corroding metal surface.

In Fig. 1 presents the results of calculations that demonstrate the main regularities of the current density distribution on the surface of the electrode. They are tied in coordinates:

$$\frac{\mathrm{ic}}{2\Delta \mathrm{E}\gamma}, \frac{\mathrm{x}}{\mathrm{c}},$$

since the spread of local current values is proportional to the value of ΔE. As can be seen, the current density (corrosion rate) is distributed similarly to the potential distribution. Since the potential distribution on the electrode surface depends on the ratio L/c, then the current density distribution should also depend on it.

Once the failure of the insulation coating is established, the question arises of predicting the leakage time due to corrosion of the pipe. In such cases, it is important to assess the condition in which the pipeline is operational.

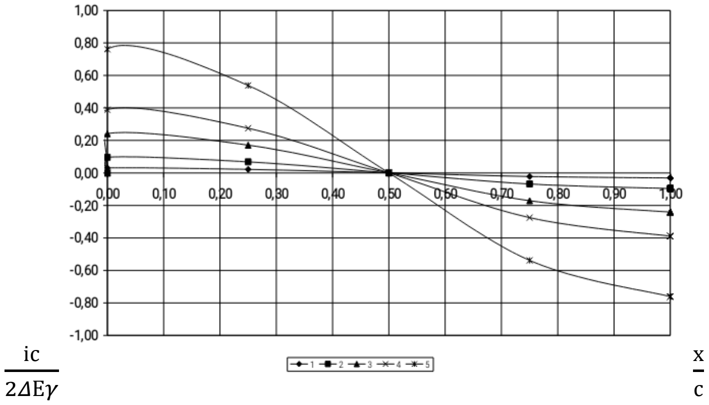

Fig. Influence of polarization on the current density distribution: a/c = 0.5; 1 − L/c = 10; 2 − L/c = 3; 3 − L/c = 1; 4 − L/c = 0.5; 5 − L/c = 0.1

The quantitative assessment of corrosion losses depends on the reduction in the wall thickness of the outer surface of the steel oil pipeline. To calculate the wall thickness with the constant presence of an aggressive electrolytic solution in the zone of damaged insulation, the dynamics of the corrosion depth of the pipeline should be studied during the operation of the galvanic cell «pipeline with damaged insulation – pipeline under the insulating coating».

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