EFFECT OF LONG-TERM OPERATION OF GAS PIPELINE ON STRESS-CORROSION CRACKING UNDER CATHODIC POLARIZATION

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Stress-corrosion cracking (SCC) of the base metal from the linear section of a main gas pipeline after 40 years of operation was investigated in near-neutral pH solution NS4. It was established that at potentials more positive than -1.050 V, SCC of unexploited pipe specimens occurs primarily through the hydrogen embrittlement (HE) mechanism. For the pipe after 40 years of service, SCC develops via mixed mechanism – anodic dissolution (AD) and HE with dominant the last one. Under these conditions, amount of hydrogen permeating into steel is approximately the same for both the unexploited and the operated pipe – 0.0296 and 0.0241 mol/dm³, respectively.

Keywords: stress-corrosion cracking, pH, hydrogen embrittlement, steel, fracture

Introduction. During operation, underground gas pipelines are exposed to combined influence of stress and corrosion [1]. Studies on pipes of various steel grades have shown that both the base metal and welded joints maintain high performance characteristics even after long-term operation [2]. Due to the initial metal's high toughness and plasticity, its condition after extended service can generally be regarded as satisfactory [3]. However, in soil environments, particularly under the combined impact of cathodic polarisation and mechanical stresses at locations under disbanded protective polymer coating the most hazardous forms of degradation is stress-corrosion cracking [4].

Research results. Studies were carried out on X70 steel specimens made from unexploited pipe and the pipe after operation for 40 years. Work solution – NS4, g/l: 0.122 KCl + 0.483 $NaHCO_3$ + 0.181 $CaCl_2$ + 0.131 $MgSO_4$, pH 8.2 [5]. Slow strain rate (10^{-6} c^{-1}) test method was used for stress-corrosion cracking investigation. Polarization potential of -1.050 V (relative to the chloride-silver reference electrode) was applied to specimens using a PI-50-1.1 potentiostat. K_S coefficient [1] was used for evaluation the susceptibility to SCC.

Analyzing the features of corrosion-mechanical fracture of specimens it was established that as the polarization potentials are shifted from -0.750 to -1.200 V, the susceptibility to SCC in NS4 changes for a new pipe from 1.02 to 1.00, for a pipe after 40 years of operation – from 1.25 to 1.86.

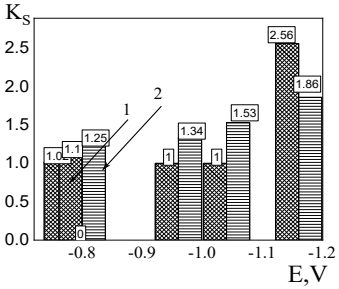

Fig. 1. Susceptibility to SCC at cathodic polarization, estimated by Ks: 1 – new pipe; 2 – pipe after 40 years of operation.

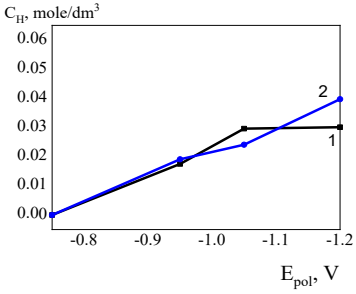

Fig. 2. Concentration of hydrogen penetrating at cathodic polarization into specimens: 1 – new pipe; 2 – pipe after 40 years of operation.

For a new pipe and a pipe after 40 years of operation – a gradual increase in hydrogenation when potential shifted from -0.950 to -1.200 V was found. For a new pipe, the amount of hydrogen increases from 0.0175 to 0.0296 mole/dm^3 when potential shifted from -0.950 V to -1.050 V and stops at a value of 0.0301 mole/dm^3 at a potential of -1.200 V. For specimens from a pipe after 40 years of operation, the amount of hydrogen gradually increases as 0.0191 $\rightarrow$ 0.0241 $\rightarrow$ 0.0397 mole/dm^3 with a potential shift of -0.950 V $\rightarrow$ -1.050 V $\rightarrow$ -1.200 V.

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