# INFLUENCE OF HYDROGEN ON THE STRENGTH OF METALS

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The advancement of technology requires an increase in the strength of structural materials while simultaneously ensuring reliability, which is determined by fracture toughness. When evaluating the strength and durability of structures, it is necessary to consider changes in the physical and mechanical properties of materials under the influence of external environments. The strength of materials is related to the regularities of crack initiation and growth in metals of various scales caused by hydrogen [1].

Currently, the significance of theoretical models is growing, as they allow for the prediction of hydrogen-induced crack growth characteristics and numerical experiments [2]. As a result, numerous hydrogen materials science centers have been established worldwide. In Ukraine, there are also well-known laboratories for its study, particularly the school of Karpenko Physico-Mechanical Institute of the NAS of Ukraine in Lviv: G.V. Karpenko, Z.Sh. Krypiakievych, Yu.I. Babey, V.I. Pokhmursky, I.I. Vasylenko, V.V. Panasyuk, V.I. Tkachev, O.E. Andreykiv, M.M. Shved, V.O. Gembara, V.I. Fedorov, and their colleagues. In the works of Andreykiv O.E., Gembara V.O., Dolinska I.Ya., et al, issues have been developed concerning the interaction of hydrogen with the surface of metal systems, its mass transfer taking into account surface reactions and the real structure of the metal, changes in physical and physicomechanical properties, and a review of methods and installations for determining hydrogen content in metals [1, 3].

The problem of hydrogen interaction with metals has emerged from other fields due to the prospects for the development of aerospace technology, nuclear, thermonuclear, and hydrogen energy, and new metal processing technologies. Hydrogen acts as a cooling element-agent in the rotors of turbo generators during electricity generation. The use of hydrogen in metal-hydrogen systems of nuclear and thermonuclear power plants is increasing, as a fuel for rocket and aviation engines and transport systems.

Accumulating technical experience in the design, construction, and operation of structures is of great importance, with significant advances in mathematical modeling of processes of hydrogen degradation of metals based on physical and mechanical theories of their deformation and interaction with hydrogen. This involves describing problems in determining the fracture toughness characteristics of materials at the crack growth stage under extreme conditions of high pressure and temperature of the environment, which complicate the measurement of crack length by optical methods during prolonged and cyclic loading. It has been found that higher-strength structural materials are more susceptible to hydrogen effects. The effect of hydrogen increases with its pressure. Therefore, the development of adequate methods for studying the hydrogen resistance of metals is necessary to ensure control over the corresponding qualities of materials and provide the necessary data for calculating the strength and durability of structures.

To solve this complex problem in metal-environment systems, the following interrelated factors have been highlighted:

a) The pressure of hydrogen gas released in the metal in micropores;

b) Hydrogen-induced decohesion in the metal lattice (weakening of adhesion forces);

c) The effect of hydrogen on dislocation mobility;

d) Surface impact (chemisorption);

e) Chemical interaction of hydrogen with alloy components, leading to the formation of hydrogen-containing compound phases (hydrides).

Research on the corrosion of metals is distinguished at different structural levels (micro and macroscopic), which is caused by increased microheterogeneity (microlocalization). At the macro level, there is a reduction in the deformation strength characteristics of metals and an increase in signs of brittle fracture. In this regard, a dislocation-decohesion concept of hydrogen's effect on metal fracture has been developed. Based on this, a problem of the residual resource of the pipeline under laminar oil flow is formulated, taking into account the degradation of the material and multiple hydraulic shock.

The solving of the developed problem will allow evaluating the residual strength and durability of the pipeline material in the working environment, which depends, in its turn, on the process rate, on temperature, and on the hydrogen environment pressure.

1. *Andreykiv O., Dolinska I., Nastasiak S., Zviahin N.* Development of a Method for Determining the Residual Life of Structural Elements with Cracks Under the Action of Load and Corrosive Environment, as well as the Application of Corrosion Inhibitors to Enhance It. Corrosion, 2024. – Vol. 80 (5) . – P. 530–538.
2. *Andreykiv O., Dolinska I., Nastasiak S., Svirchevskyi O.* Propagation of High-Temperature Creep Cracks in Metals Under the Influence of Hydrogen and Neutron Irradiation. Procedia Structural Integrity, 2024. – Vol. 59. – P. 182–189.
3. *Pelekh B. L., Syasky, A. A.* Stress distribution around holes in shear-compliant anisotropic shells. Kyiv: Naukova Dumka, 1975. – 197 p.

**ВПЛИВ ВОДНЮ НА МІЦНІСТЬ МЕТАЛІВ**

*Сформульовано задачу про залишковий ресурс трубопроводу за ламінарного потоку нафти з урахуванням деградації матеріалу і багаторазових гідроударів.*