All these factors (formation of a short-range order in the alloys, refining of the blocks, and increase of the microstrains in the crystal lattice, as well as the formation of a phase with all the distribution of the hydrogen atoms), determined by an increase of the hydrogen concentration of the alloys, complicate the formation, multiplication, and displacement of dislocations and, consequently, increase the strength.

As regards the fact that the palladium-platinum-tungsten alloy retains high relative elongation values, we can propose the following explanation. Ordered distribution of the hydrogen atoms, formed during preliminary saturation of the alloys in subsequent deformation, undergoes changes which create the conditions for the operation of effects similar to those detected in a wide range of materials and referred to as transformation-induced plasticity. In addition, uniform and homogeneous distribution of hydrogen over the entire volume of the alloy prevents the formation of stress raisers and nucleation and propagation of cracks. This also increases strength without reducing ductility.

Thus, the investigations show that it is possible to use the alloys of the palladium-platinum-tungsten system as basic alloys in developing new high-strength processing materials suitable for long-term service in hydrogen at elevated temperatures and pressures.

LITERATURE CITED


HYDROGEN PERMEABILITY OF NONSYMMETRIC METALLIC MEMBRANES

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The problem of examining hydrogen permeability (HP) of metallic membranes nonsymmetric as regards the surface state involves a relatively wide range of membranes and processes taking place during their interaction with a gas.

We examine the process of HP in a membrane with thickness l, with one side of the membrane coated with a relatively thin coating. Consequently, the diffusion time in this coating is considerably shorter than the diffusion time in the substrate material. In addition,
the thin metallic films on the surface are usually characterized by high porosity and heterogeneity. Therefore, this problem can be described by a system of equations with boundary conditions considering the nonsymmetry of the surface processes \[1\]:

\[
\frac{dn}{dt} = D \frac{d^2 n}{dx^2} + \frac{b}{g + gD} \frac{dn}{dx}, \quad x = 0; \tag{2}
\]

\[
\frac{dn}{dt} = -2b_2 \frac{n_2}{g} - gD \frac{dn}{dx}, \quad x = l. \tag{3}
\]

Here \(n\) is the volume concentration of hydrogen, \(t\) is time, \(x\) is the coordinate, \(b\) is the constant of the desorption rate, \(g\) is the constant of the volume-surface equilibrium, \(D\) is the diffusion coefficient, \(\gamma_1\) and \(\gamma_2\) are the coefficients of activity of different size of the membrane taking into account the catalytic properties on the surface, \(n_c = K_S / P\) is the equilibrium constant, where \(K_S\) is Sieverts' constant (solubility of hydrogen in the specimen), \(P\) is the pressure of the gas on the inlet side of membrane (\(P_{x=0} = 0\)).

Solving this system for a stationary case, we obtain the equation of the permeability isothermal which specifies the relationship of the numerical flow with the gas pressure \(P\):

\[
P = S_1' J^2 + 2S_2 J^3 + (S_1' + S_3') J, \tag{4}
\]

where

\[
S_1 = \frac{l}{(DK_C)}, \quad S_2 = \frac{g}{(K_S V^2 b_1 \gamma_1)}, \quad S_3 = \frac{g}{(K_S V^2 b_2 \gamma_2)}.
\]

Equation (4) makes it possible to calculate the parameters \(S_1, S_2,\) and \(S_3\) by the method of least squares in processing the experimental data. The permeability of membrane is determined from the value of \(S_1\)

\[
\rho = J_R P^{-1/2} = DK_S = l/S_1, \tag{5}
\]

where \(J_R\) is the stationary flow.

To determine the remaining parameters of the process (\(D, K_S, b, g, \gamma_1, \gamma_2\)), it is necessary to process jointly the experimental results using Eq. (4) and the system of Eqs. (1)-(3).

In the case in which it is not possible to ignore the diffusion time in the coating, it is necessary to examine the two-zone problem of diffusion of hydrogen in the coating and the substrate (matrix) with a corresponding equation for the concentration at the boundary between them. The stationary solution of this system leads to an equation of the permeability isotherm similar to the equation (4), where \(S_1' = \frac{l_1}{(D_1 K_{S1})} + \frac{l_2}{(D_2 K_{S2})}, S_2' = \frac{g_1}{(K_{S1} \sqrt{2b_2 \gamma_1})}, S_3' = \frac{g_2}{(K_{S2} \sqrt{2b_2 \gamma_2})}, l_1\) is the thickness of the coating, \(l_2\) is the thickness of the substrate, the indexes 1 and 2 denote the constants for the coating and the matrix, respectively. The reduced parameters were obtained on the condition

\[
n_1/n_2 = K_{S1}/K_{S2}, \quad x = l_1.
\]

The permeability of bimetallic membranes under boundary conditions of the first kind will be determined from the available values of permeability of the matrix \(\rho_m\) and the coating \(\rho_c\) [2]:

\[
\rho = \frac{\rho_m \rho_c (l_1 + l_2)}{(\rho_m l_1 + \rho_c l_2)}. \tag{6}
\]