INVESTIGATION OF HYDROGENATION PARAMETERS INFLUENCE ON THE HYDROGEN SORPTION RATE OF TITANIUM ALLOY VT1-0 COATED BY NICKEL LAYER

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ИССЛЕДОВАНИЕ ВЛИЯНИЯ ПАРАМЕТРОВ НАВОДОРОЖИВАНИЯ НА СКОРОСТЬ СОРБЦИИ ВОДОРОДА ТИТАНОВЫМ СПЛАВОМ ВТ1-0 С НАНЕСЕННЫМ СЛОЕМ НИКЕЛЯ

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Аннотация. *Проведено исследования влияния параметров наводороживания на скорость сорбции водорода титановым сплавом ВТ1-0 с нанесенным слоем никеля. Показано, что при увеличении одного из параметров наводороживания увеличивается скорость сорбции водорода. Также с увеличением времени нанесения покрытия уменьшается скорость сорбции водорода.*

Titanium and its alloys are used as construction materials in different industries, such as aircraft and chemical industries, etc. [1]. The problem of hydrogen embrittlement is especially topical for titanium alloys. Hydrogen has very strong effect on the physical, chemical and mechanical properties of the metal and alloys [2]. The stages of hydrogen penetration into metal are as follows: physical adsorption of molecule, hydrogen dissociation, atom absorption and diffusion in volume. If the entire surface of the sample is in contact with hydrogen after some time during the reaction at a given temperature, the process completes with uniform distribution of metal throughout the metal [3]. Another important factor in interaction of hydrogen with a metal is a surface. For example, to prevent penetration of hydrogen a surface modification [4], as well as the deposition of protective coatings is possible [5]. On the other hand, it is possible to increase hydrogen sorption rate by applying thin layers of nickel and palladium to the metal surface [6]. When performing the hydrogenation of the gaseous medium, the important parameters are temperature and hydrogen pressure in the reaction chamber [7]. Thus, there is the problem of determining the effect of hydrogenation parameters on hydrogen sorption rate VT1-0 titanium alloy with nickel coating.

Materials and method of research. The rectangular flat samples of VT1-0 alloy with the fixed size of 20x20x1 mm were used for the experiments. The samples were previously polished using sandpaper with a surface roughness of Ra≈0.05 μm to remove the oxide layer. Then the samples were subjected to sputtered cleaning, followed by applying a layer of nickel using «Raduga Spectr» technique. Hydrogen saturation of the samples was performed by Sievert’s method on the automated complex Gas Reaction Controller LPB. After saturation of the samples from the gaseous medium we can plot curves for hydrogen sorption using the obtained experimental data. The sorption rate at the initial stage of the absorption can be calculated from the data by drawing an average straight line to the initial linear region of the line. Then, the natural logarithm of hydrogen sorption rate against the temperature in Kelvin minus one is plotted. The approximation straight line for determining the slope of the line is plotted to these points. The resulting value is multiplied by universal gas constant and the product will be the activation energy of hydrogen sorption.

Study results. Figure 1 shows the curves of hydrogen sorption by VT1-0 titanium alloys with a coated nickel layer at temperatures of 350 °C, 450 °C, 550 °C and pressures 1 atm., 1,5 atm. and 2 atm.

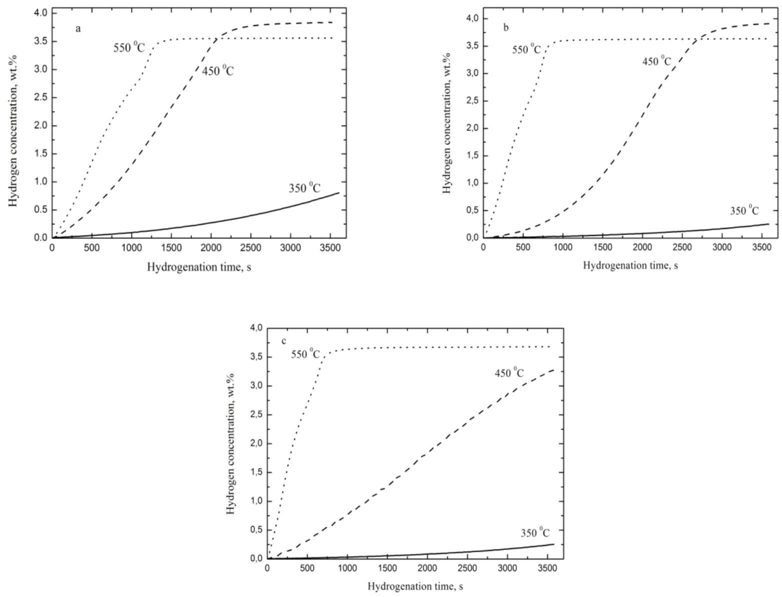

Fig. 1. Curves of hydrogen sorption by VT1-0 titanium alloys with a coated nickel layer at temperatures of 350 °C, 450 °C, 550 °C and pressures a) 1 atm., b) 1,5 atm., and c) 2 atm.

It is seen that increased rate of hydrogen sorption occurs with increasing the pressure at constant temperature. Similar effect occurs with increasing temperature at constant pressure (Table 1).

Table 1

Hydrogen sorption rates at different pressures and temperatures

№	Temperature, °C	Pressure, atm	Sorption rates VT1-0+Ni, $*10^{-4}$ wt.%/s
1	350	1	2,2
		1,5	0,66
		2	0,65
2	450	1	17,8
		1,5	14,8
		2	9,9
3	550	1	27,1
		1,5	43,9
		2	49,2

It was found that with increasing the pressure when saturating samples with a coated nickel layer from gaseous medium, the activation energy of hydrogen sorption increases. Figure 2 shows the curves of hydrogen sorption by VT1-0 titanium alloys at temperature of 450 °C and pressure 2 atm. with different times of nickel coating.

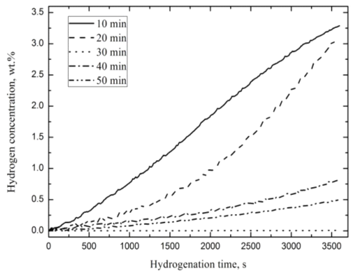

Fig. 2. The curves of hydrogen sorption by VT1-0 titanium alloys at temperature of 450 °C and pressure 2 atm. with different times of nickel coating

It is shown that the hydrogen sorption rate decreases when time of coating is increased. The results of hydrogen sorption rate measurements are given in Table 2.

Table 2

Hydrogen sorption rates by titanium with nickel coating at temperature of 450 °C and pressure 2 atm.

№	Time coating process, min	Sorption rates VT1-0+Ni, $*10^{-4}$ wt.%/s
1	10	9,90
2	20	8,54
3	30	3,49
4	40	2,12
5	50	1,36

Conclusion. Based on these results, the following conclusions can be made:

depending on the time of coating at constant parameters of hydrogenation, the rate of hydrogen sorption by titanium alloy is reduced; hydrogen sorption rate is increased with increasing pressure at constant temperature, and with increasing temperature at constant pressure.

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