ABOUT INTERACTION OF HYDROGEN WITH SPHERICAL PARTICLES OF BT5-1 TYPE ALLOY

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Introduction

Titanium and its alloys find a wide application in a science and engineering. At the increased temperatures they react actively with gas impurities present in an atmosphere, forming thus a number of solid solutions and the phases of introduction, which essentially change the original physico-chemical and physico-mechanical properties of initial alloys. So, in a case with hydrogen the embrittlement of titanium-containing alloys occurs. In the literature there is a number of theoretical and experimental works describing an influence of hydrogen on processes of hydrogenation and brittle failure of various metals and alloys, for example [1–4].

In the present work the experimental data about interaction of hydrogen under pressure of 1–6 MPa at the temperatures 773–973 K with spherical particles of an alloy on a basis of titanium such as BT5-1 are submitted.

Results and discussion

As model object the spherical particles of an alloy by a diameter of 0.1, 0.4, 0.6 and 0.8 mm were used. On the data of the chemical and microröntgenospectral analyses, the spherical particles of an alloy contained 92.05 mass. % of Ti, 4.52 mass. % of Al and 3.43 mass. % of Sn. According to the results of the X-ray phase analysis, the initial alloy is homogeneous and represents a solid solution of aluminium and tin in α-titanium crystallizing in a hexagonal syngony with the following parameters of a lattice: a = (0.2959 ± 0.0002)nm, c =(0.4670 ± 0.0003)nm.

The interaction of alloys with hydrogen was conducted in the laboratory plant of high pressure with preliminary degassing samples under a vacuum at 523 K during 1 h.

The hydrogenation of spherical particles of an alloy BT5-1 proceeds without the induction period at 793 K with exothermic effect, therefore a temperature in autoclave raises up to 820 K. The content of hydrogen in hydrogenation products answers the composition $Ti(Al,Sn)H_{1.8}$. On the difractograms of products of hydrogenation only the reflexes of titanium dihydride are observed with the parameter of a crystal lattice a = 0.4434–0.4437 nm (for $TiH_{1.92}$ a = 0.4448 nm). The reduction of a diameter of particles of an alloy results in appreciable decrease of time of sample saturation by hydrogen: with 4 h at a diameter of particles of 0.8 mm up to 10 min at a diameter of particles of 0.1 mm.

In figure the microphotos of spherical particles of an alloy BT5-1 by a diameter of 0.6 mm are submitted in an initial condition (a) and after realization of one (b), five (c) and ten (d) cycles of sorption-desorption of hydrogen.

It was established that already after the first cycle of sorption-desorption of hydrogen about 90% of particles of an initial alloy become covered by cracks, after 5 cycles – 100%. With increasing amount of cycles (from 1-st to 10-th) there is also simultaneous deepening cracks and breaks. As a rule, process of hydrogenation and accompanying phenomenon of a formation of cracks are connected to defects (bowls and breaks) of the surfaces of initial samples. The similar picture is observed and for other sizes of spherical particles of an alloy BT5-1.

The hydrogenation of particles of an alloy BT5-1 in hard conditions – at temperature 973 K and pressure of hydrogen up to 6 MPa – does not result in increase of the content of hydrogen in an alloy: it remains former and corresponds to composition $Ti(Al,Sn)H_{1.8}$.

For initial alloy and the hydrogenation products the values of microhardness are measured (at loading P = 50 g), which have appeared equal 337 ± 50 and 565 ± 51 kg/mm^2, accordingly.

The thermal stability of hydrogenation products $Ti(Al,Sn)H_{1.8}$ is lower, than a stability of titanium dihydride. On the thermogravіagrams of samples three endothermal effects are observed, and besides ~20% of the hydrogen absorbed by an alloy is isolated already at 783 K and 823 K, and the rest of hydrogen amount is isolated at 900 K.

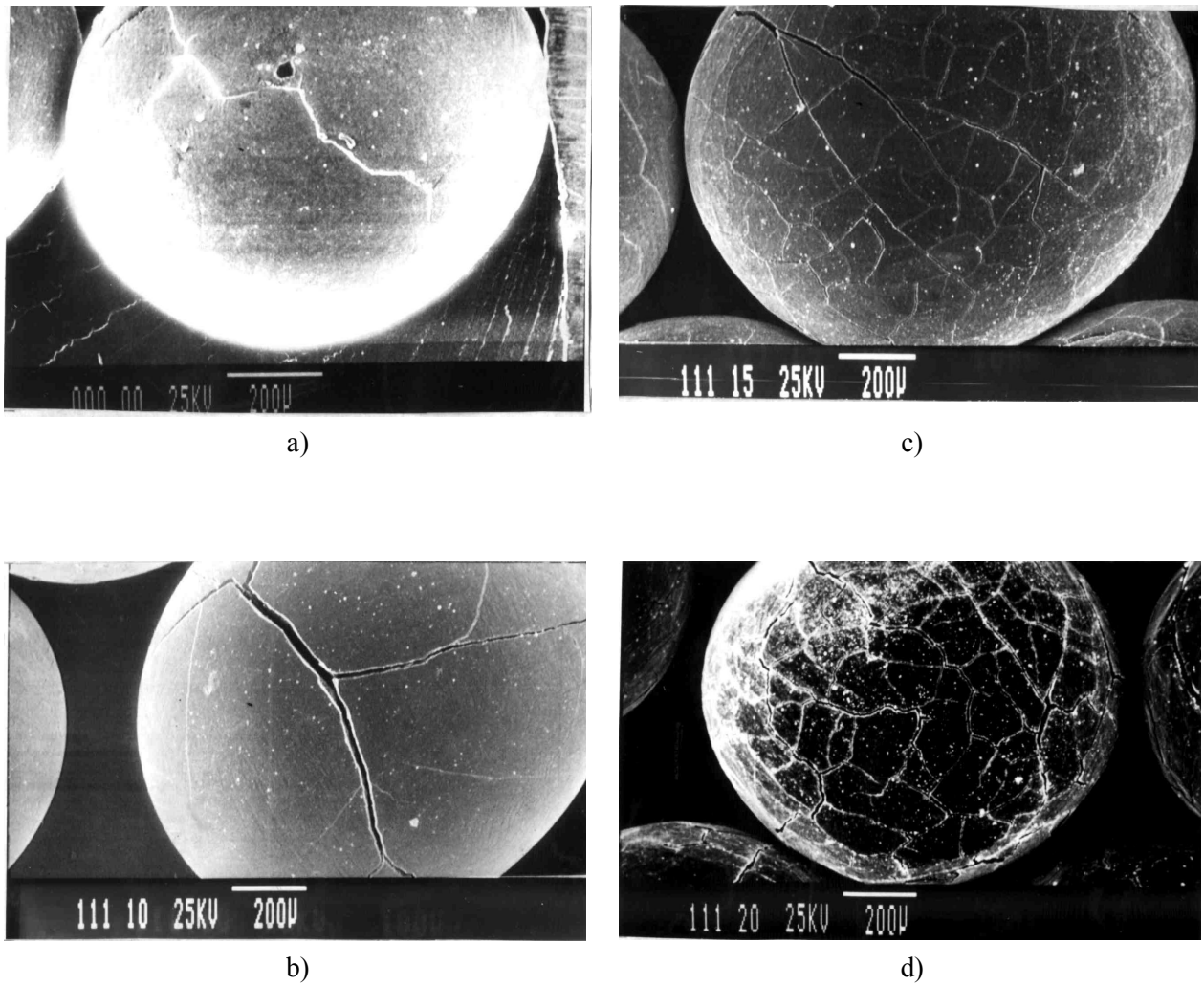
Conclusions

The interaction of hydrogen with spherical particles of an alloy such as BT5-1 containing 92.05 mass. % of Ti, 4.52 mass. % of Al and 3.43 mass. % of Sn with diameters of particles of 0.1, 0.4, 0.6 and 0.8 mm was investigated at

temperatures of 820-973 K and pressure of 1–6 MPa. It was shown that the alloy has the lower absorbed capacity on hydrogen in comparison with titanium and thermal stability of the hydrogenated alloys is essentially lower than a stability of titanium dihydride.

References

1. Kornev V.M. Zh. prikl. mechaniki i tekhn. fiziki, 1998;39 (3):173-178 (in Russian).
2. Ustinov V.S., Olesov Yu.G., Drozdenko V.A., Antipin L.N. Powder metallurgy of titanium. M.: Metallurgy, 1981. 247 pp. (in Russian).
3. Andrievsky R.A. Material Science of Hydrides. M.: Metallurgy, 1986. 129 pp.
4. Lavrenko V.A., Antonova M.M., Shemet V.Zh. Kinetics of processes in hydride systems. Kiev: Naukova dumka, 1992. 188 pp.



a) c)

b) d)

Fig. Microphotos of spherical particles of an alloy BT5-1 by a diameter of 0.6 mm in an initial condition (a) and after realization of one (b), five (c) and ten (d) cycles of sorption-desorption of hydrogen (increase x75).