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EFFECT OF CHANGE THE PALLADIUM CONTENT ON MECHANICAL CHARACTERISTICS OF TWO-PHASE SYSTEM Pt-Pd ALLOYS

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ABSTRACT

In order to supplement the existing database with the new results on platinum and platinum metals, originating from the site in the Mining Basin Bor, the investigations were carried out for the two-stage system of Pt-Pd alloys. Hardness and tensile strength were tested for all concentration area (10-90% (at)) of palladium. High temperature strength was also determined for the following compositions: Pt-10% (wt.) Pd and Pt-15% (wt.) Pd in the temperature range from 1100 to 1400^{o}C.

Keywords: Pd, mechanical characteristics alloys, Pt-Pd system

1.INTRODUCTION

Today, in the world, platinum is irreplaceable in the high-temperature oxidation environments, where the presence of chemical erosion is unacceptable. The use of pure metal is limited due to the low strength and creep resistance at high temperatures. Also, the high price of this metal limits its application.

In the solid solutions of platinum with Pd, Rh, Ru, Ir and Au, the resistance as well as the strength at high temperatures are defined by interatomic forces of connection and structure what involves the microstructure (grain size, nature and composition of grain boundaries, subgrain size and mode of their orientation), dislocation structure (movement and distribution of dislocations) and macrostructure (presence of pores, voids or other defects).

In order to reduce and prevent the creep of platinum at high temperatures and stresses, it is necessary to slow the diffusion mobility of the same.

In introduction of palladium as the alloying element in platinum, with creation of a continuous range of solid solutions, one of tested effects is the effect of platinum strengthening with palladium.

Platinum and platinum metals were a challenge for many researchers [1-3].

Addition of palladium, as the alloying element in platinum, in order to change the color of high noble dental alloy, was the subject of research [4,5].

The thermal stability, mechanical properties and effect of palladium on already formed palladium preparations and thin films, based on precious metals, were studied [6-8].

The use of Monte Carlo simulation to describe the surface segregation of Pt-Pd alloys using the MAEA method was the goal of research [9].

The mobility and diffusivity in Co-X (X = Pd, Pt, Au, Ag, Cu) alloys [11] was tested as well as the ion microscopy was used to determine the phase transformations in Cu_2Au(Pt,PdAg) alloys [10].

There are a number of studies of hydrogen effect on segregation in the alloys of precious metals [12,13].

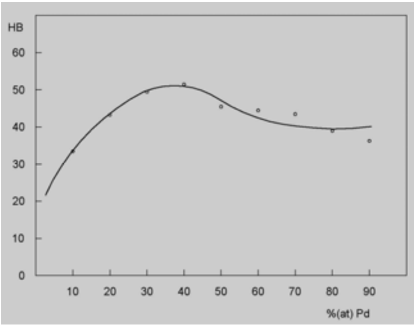
The two-phase system Pt-Pd, Pt-Rh, Pd-Rh and the ternary system Pt-Rh-Pd were studied using the MEAM method [14].
However, despite numerous studies, the methods of platinum hardening are always actual with the aim of achieving the effect of high-temperature strength the platinum - palladium alloys with simultaneous increase the exploitation time of the same.
The aim of this work was testing the effect of change the palladium content on.

2. MATERIALS AND TESTING TECHNIQUES

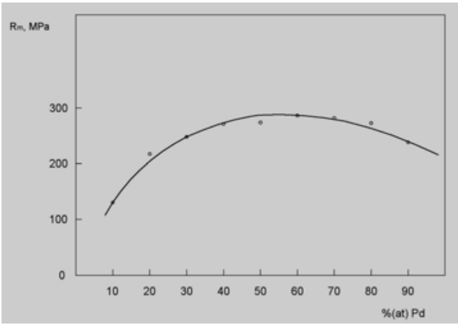
All experimental tests with the presented results in this paper were carried out on samples of pure platinum (99.95%) and palladium (99.5%).
Platinum and palladium for production of all samples originating from the production of electrolytic copper in RTB, obtained as by-products. Using the additional refining in the Mining and Metallurgy Bor resulted in purity of the same, required for production of samples. The impurities in tested samples were characteristic for the raw material of the Bor site - Pd, Ag, Au, Bi, Sb, As, Cu.
Melting of samples was carried out in the medium frequency induction furnace. Annealing of samples was carried out in the electric resistance furnace, type LP08.
Testing the lasting strength and elongation at high temperatures, was done on the "Mayes" MK 2 TC/10 – English manufacturer, with samples of standard dimensions and shapes for this type of testing.
Chemical analysis of material for samples was done on the device AAS.

3. RESULTS AND DISCUSSION

The results of hardness (HB) dependence of a) cold deformed samples, and tensile strength (R_m), b) are shown in Figure 1.



a)



b)

Figure 1. Dependence HB a) and R_m b) on palladium content in the alloys Pt-Pd

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The results of dependence the tensile strength of two-phase system Pt-Pd alloys on the content of palladium in the temperature interval 1200-1400^{o}C, at stress of 5 MPa are shown in Figure 2.

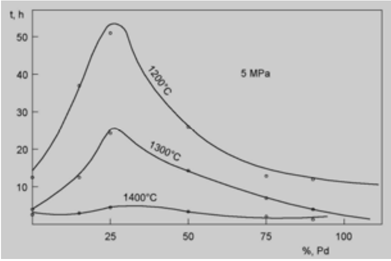

Figure 2. Dependence of time to the fracture of composition the Pt-Pd alloys at temperatures of 1200^{o}C (1), 1300^{o}C (2), 1400^{o}C (3) and stress of 5 MPa

Based on presented results, and with the aim of creating a database for platinum and platinum metals from raw materials of the Bor deposit, the mechanical properties of Pt-Pd alloys are determined in the whole concentration area of palladium as well as the mechanical properties of composition the Pt-10%Pd and Pt-15% Pd alloys at high temperatures. To the aim of comparative analysis, the values of mechanical properties for pure platinum are shown.

It can be concluded that the strength of alloys, at elongation at room temperature, is maximum for the composition of Pt-60% Pd. With the increase of palladium as the alloying element, the plasticity of alloys increases.

In order to investigate the hardening effect of platinum by addition of palladium as the alloying element, the tensile strength of alloys is determined in the whole concentration area of palladium in the temperature range 1200-1400^{o}C and stress of 5 MPa.

The conclusion is that the high-temperature resistance of alloys in the studied conditions increases with the content of palladium up to 25-27%. This effect was particularly observed at temperature of 1200^{o}C. At 1300^{o}C, the effect is less pronounced, while at 1400^{o}C, it is completely absent – the alloying of platinum with palladium, in this case, does not lead to the resistance increase at high temperatures.

With increase of palladium content above 60%, the tensile strength at all temperatures decreases. Considering that the melting temperature of palladium is lower compared to the pure platinum, the high temperature testing (1300 and 1400^{o}C) and at high contents of palladium, the diffusion mobility has significantly increased in the alloy, resulting in decrease of high-temperature resistance of the Pt-Pd alloy system.

3. CONCLUSIONS

In order to determine the mechanical properties of alloys of the Pt-Pd system at room temperature, the testing were carried out in the whole concentration area of palladium of two-phase system.

Furthermore, in order to investigate the effect of platinum strengthening buy addition of palladium as the alloying element, the tensile strength of alloys was determined in the whole concentration area of palladium in the temperature range 1200-1400^{o}C and stress of 5 MPa.

Tensile strength of alloys, at elongation at room temperature, is maximum for the composition of Pt-60% Pd. With increasing of palladium content, as the alloying element, the plasticity of alloys increases.

High temperature stability of the alloys in the studied conditions increases with palladium content to 25-27%. This effect is particularly observed at temperature of 1200^{o}C.

Considering that the melting temperature of palladium is lower compared to the pure platinum, the high temperature testing (1300 and 1400^{o}C) and at high contents of palladium, the diffusion mobility of the alloying element has significantly increased in the alloy, resulting in decrease of high-temperature resistance of the Pt-Pd alloy system.

4. ACKNOWLEDGEMENTS

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