THE INFLUENCE OF RHODIUM CONTENT ON THE MECHANICAL PROPERTIES OF PLATINUM

Biserka Trumić[1], Aleksandra Ivanović[1], Saša Marjanović[2], Draško Stanković[1], Silvana Dimitrijević[1], Stevan P. Dimitrijević[3]

[1]Mining and Metallurgy Institute Bor, Zeleni bulevar 35, 19210 Bor, Serbia,
e-mail: biserka.trumic@irmbor.co.rs

[2]Technical Faculty Bor, University of Belgrade, V.J. 12, 19210 Bor, Serbia,
e-mail: smarjanovic@tf.bor.ac.rs

[3]University of Belgrade, Innovation center of the Faculty of Technology and Metallurgy,
Karnegijeva 4, 11000 Belgrade, Serbia

ABSTRACT

The paper presents the results of investigation the influence of rhodium as an alloying element on the mechanical properties of platinum. A short-term and tensile strength were tested, at room and high temperatures, and also sliding rate and time to the destruction of the Pt-Rh system alloys at high temperatures. The results showed that alloying with rhodium strengthens the platinum while reducing its plasticity. Time to destruction is much longer in Pt-Rh alloys compared to pure platinum.

***Keywords**: platinum, platinum alloys, rhodium, mechanical properties*

1 INTRODUCTION

Phase diagram of the system Pt-Rh is characterized by a complete solubility of input components at temperatures higher than 600°C. Temperatures below 600°C lead to decomposition of the solid solution. Properties of Pt-Rh alloys are well investigated because these alloys are of great importance for practical application due to the great strength at room and high temperature. Alloys containing up to 20% Rh are cold processed without major difficulties [1-3]. Alloys with 20% Rh and more are warm processed on the rotary forging machine. The alloys with 5; 7; 10 and 15% Rh are of the greatest practical importance. The alloys with rhodium content of 1 to 30% are used for production of thermocouples [4].

2 EXPERIMENTAL PART

The composition of tested samples is given in Table 1.

Table 1 *Composition of tested samples (in mass%)*

Alloy	Pt (mass%)	Rh (mass%)
Pt	100	0
PtRh5	95	3
PtRh7	93	7
PtRh10	90	10
PtRh15	85	15
PtRh20	80	20

Melting of samples was carried out in the medium-frequency induction furnace. Annealing of the samples was carried out in an electric furnace type LP08.

For testing the mechanical properties of samples at high temperatures, a universal machine for tensile testing of materials at high temperatures was used, manufacturer Karl Frank, type 81221.

3 RESULTS AND DISCUSSION

Tensile strength of the alloys Pt-5%Rh and Pt-10%Rh at room and high temperatures (300-1.250°C) was investigated and the results are shown in Table 2, and short-term strength of these alloys was also tested at the same temperatures in the time of 100 h. A wire of thickness 2 mm and a length of 300 mm was used as a sample, subjected to recrystallization annealing in the air, prior to testing.

Table 2 *Short-term and tensile strength of the Pt-Rh system alloys at different temperatures*

Testing temperature, °C	PtRh5			PtRh10		
	R_m, MPa	R_{100}, MPa	R_{100}/R_m	R_m, MPa	R_{100}, MPa	R_{100}/R_m
20	225	202	0.90	287	265	0.92
300	170	151	0.89	256	205	0.80
500	137	109	0.79	183	147	0.80
700	103	50	0.49	150	74	0.49
900	71	17	0.24	107	27..	0.26
1,100	36	7.7	0.21	59.5	12	0.20
1,250	30	5.7	0.19	-	-	-

Alloying with rhodium strengthens platinum, wherein the high-temperature strength is related to the reduction of diffusional movement by the presence of alloying element with a higher melting point as compared to a pure platinum. In practice, the greater percentage of the rhodium in the alloy, the greater the strength of the alloy at specified temperature. Also, alloying with rhodium leads to the reduction of plasticity.

Properties of platinum alloys with rhodium containing from 7 to 20% Rh were also investigated. The tests were confined to micro hardness at room temperature, and also on tensile strength and plasticity at 1,100; 1,200; and 1,400°C of alloys with 7; 10; 15; and 20% Rh. The test results are given in Table 3.

Table 3 *Short-term high-temperature strength and plasticity of alloys*

Alloy	H_μ	R_m, MPa 1,100°C	A, % 1,100°C	R_m, MPa 1,200°C	A. % 1,200°C	R_m, MPa 1,300°C	A, % 1,300°C	R_m, MPa 1,400°C	A, % 1,400°C
Pt-99,9	74	25	31	18	35	13	50	7	56
PtRh7	110	53	31	44	31	35	32	20	34
PtRh10	153	56	32	46	32	37	34	22	34
PtRh15	185	59	34	48	37	38	40	23	44
PtRh20	229	69	34	56	36	42	36	26	38

For comparison reasons, the results for pure platinum are also given. Deformation speed was 6 mm/min. All samples were tested after recrystallization. Modulus of elasticity of platinum alloys with 7 and 10% Rh is $17.2 \cdot 10^4$ MPa.

Alloying of platinum with rhodium significantly increases the strength. The effect of increasing the strength at temperatures of 1.300 and 1.400°C was particularly. The strength of the alloy with 20% Rh increases 3-3.5 times as compared to pure platinum. Alloying with 7% Rh increases the scope of strength compared with pure platinum by as much as two times at all temperatures, and even three times at 1,400°C.

Comparing the obtained results it was concluded that time to rupture of platinum alloy with 10% Rh is almost ten times longer than that of pure platinum at 1,200°C, and 20 times longer at 1,300°C.

There were also performed measurements of high-temperature resistance of Pt-Rh alloys when stretched in the air in temperature range 1,200-1,600°C. Figure 1 shows the concentration dependence of the sliding speed of platinum alloys at 1,400 and 1,600°C.

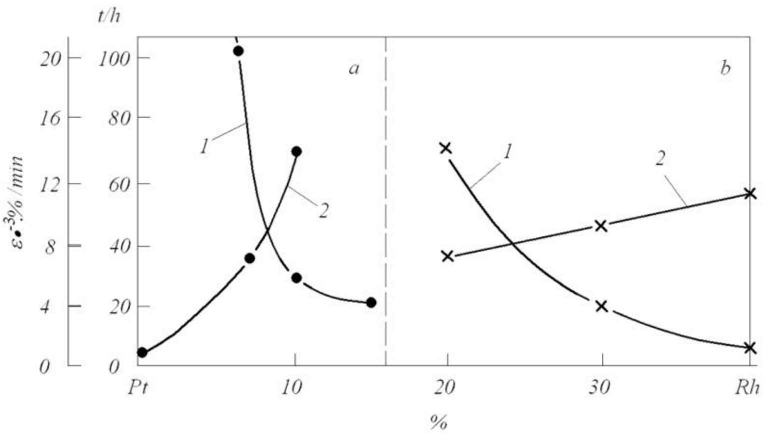

Figure 1 *The dependence of sliding speed ε (curve 1) and the time to rupture t (curve 2) on composition of the Pt-Rh alloys at 1,400 °C (a) and 1,600 °C (b)*

At all testing temperatures, the high-temperature resistance by certain rules increases with increasing concentration of rhodium in the alloy.

CONCLUSION

The results of investigations the effects of the addition of rhodium, as alloying element, on mechanical properties of pure platinum, showed the following:

- Alloying with rhodium strengthens the platinum, and reduces its plasticity, both at room and at high temperatures.
- Also, the addition of rhodium increases the time to rupture of the alloy, compared with pure platinum.
- With increasing concentration of rhodium in the alloy, its high temperature resistance also increases.

ACKNOWLEDGEMENTS

The research presented in this paper was financially supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, as a part of the Project No. TR 34029.

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