Creep Tests on Platinum Alloys

A NEW METHOD OF ASSESSING HIGH-TEMPERATURE PROPERTIES

In a recent paper on the tensile creep properties of platinum and a number of its alloys (1), Dr G. Reinacher of Degussa, Hanau, has extended the information presented in two earlier papers (2, 3), and has advanced intriguing explanations for some of the anomalously low elongation values that have been observed.

The behaviour of physically pure (as opposed to commercially pure) platinum was compared with that of platinum alloyed with 4 per cent of palladium, 5 per cent of rhodium, 10 per cent rhodium, 5 per cent iridium, 10 per cent iridium, 5 per cent of gold, and 4 per cent of ruthenium over the temperature range 20 to 1250°C. Tensile creep tests were carried out in air for periods extending up to 100 hours. The specimens were in the form of 2 mm diameter wire and elongations were determined over a gauge length of 50 mm. Wires were selected from standard production batches, and although no purity figures are quoted, all the specimens were pre-annealed at temperatures comparable to those at which they were to be tested so as to stabilise the grain structure.

An Index of Resistance to Creep

Some of the more important results are summarised in the table, which compares the tensile stress f_{100} each material was capable of withstanding for 100 hours with the stress f_0 which caused instantaneous failure at the same temperature. The ratio of these two values affords a valuable index of the resistance to creep, and the rapid rate at which this index decreases with rising temperature should be observed. The concept of a "temperature coefficient of creep resistance" is introduced at this stage and used to compare the relative behaviour of the various test materials.

At 1100°C, the maximum temperature at which a complete range of data was available, the 10 per cent rhodium-platinum alloy was the strongest material tested. This was closely followed by the 10 per cent iridium and 4 per cent ruthenium-platinum alloys which had very similar characteristics. The physically pure platinum had a 100 hour loading capacity approximately half that of the ruthenium alloy and slightly higher than that of the 4 per cent palladium alloy. At temperatures below 500°C the iridium-platinum alloys were superior to rhodium-platinum alloys.

As opposed to the pure platinum and the 4 per cent palladium-platinum alloy, both of which displayed considerable ductility over the whole temperature range studied, intercrystalline failures within the intermediate temperature ranges occurred with the iridium and rhodium-platinum alloys, and elongation minima were observed in the range 900 to 1100°C. Elongation values as low as 3 and 7 per cent at 500° and 700°C occurred with the 5 per cent gold alloy, and the 4 per cent ruthenium alloy had a sharply defined ductility minimum at 1100°C. At 900°C, where the rhodium and iridium-platinum alloys had elongation minima, the ruthenium-platinum alloy showed its highest elongation values.

Boundaries of Low Ductility Regions

Dr Reinacher concludes that the boundary of the high temperature ductility region corresponds with the temperature at which rapid grain growth occurs and the microscopic evidence confirms that the fine-grained materials are much less ductile than those in which grains extend across the specimen. In order to confirm a suspicion that atmospheric oxidation contributed to the ultimate

Creep Resistance of Platinum and Platinum Alloys at Temperatures up to 1250°C

(Tons per square inch)

Temp. °C	Pure Pt		4% Pd-Pt		5% Rh-Pt		10% Rh-Pt	
	f_0	f_{100}	f_0	f_{100}	f_0	f_{100}	f_0	f_{100}
20	8.57	7.87	14.1	13.02	14.28	12.95	18.2	16.8
300	6.40	5.14	11.37	10.17	10.78	9.57	16.5	13.0
500	4.86	2.92	9.27	6.35	8.70	6.92	11.6	9.39
700	4.11	1.46	6.80	3.30	6.54	3.18	9.54	4.7
900	2.13	0.76	4.37	1.19	4.50	1.08	6.8	1.74
1100	1.14	0.32	1.50	0.32	2.28	0.49	3.78	0.76
1250	0.89	0.25	0.96	0.18	1.90	0.36	—	—

Temp. °C	5% Ir-Pt		10% Ir-Pt		5% Au-Pt		4% Ru-Pt	
	f_0	f_{100}	f_0	f_{100}	f_0	f_{100}	f_0	f_{100}
20	15.5	13.85	22.86	21.25	22.4	20.3	28.0	25.4
300	13.9	10.6	17.15	16.2	19.6	—	19.55	—
500	10.1	5.7	13.7	9.26	19.05	8.15	18.7	14.3
700	6.73	2.80	9.72	3.75	13.3	3.62	12.6	6.66
900	4.25	0.81	5.65	1.27	7.42	1.40	8.05	2.10
1100	2.06	0.44	3.20	0.61	2.98	0.41	3.59	0.60
1250	1.36	0.30	2.38	0.32	1.84	0.24	—	—

f_0=stress required to cause instantaneous failure

f_{100}=stress required to cause failure in 100 hours

failure of the rhodium and iridium-platinum alloys, special platinum-sheathed test specimens were produced but the results obtained were unfortunately not reported.

The value of the index f_{100}/f_0 which, at room temperature, was approximately 0.9 for all the materials tested, decreased rapidly as the temperature increased above 500°C, reaching 0.2 at 1100°C and in some instances 0.15 at 1250°C. At 1100°C the 100 hour loading capacity of the 10 per cent rhodium alloy is only 20 per cent of its hot tensile strength, while that of physically pure platinum, surprisingly enough, is 28 per cent of its hot tensile strength. The high temperature properties of pure platinum, therefore, although inferior to those of its alloys, do not decrease so rapidly with temperature.

The data in the table indicate the existence of what might be termed a plateau of creep resistance, extending with some alloys up to 500°C, over which the mechanical properties deteriorate only to a limited extent. The rapid deterioration which occurs at higher temperatures suggests that a simple "temperature co-efficient of creep resistance" is not applicable over wide temperature ranges, although it may be of considerable value in comparing the properties of the various platinum alloys between 900° and 1250°C.

Interesting speculations on the influence of miscibility gaps on creep behaviour are advanced by the author, who suggests that the intermediate-temperature brittleness exhibited by the gold and iridium-platinum alloys might be associated with a type of precipitation which is accelerated under the influence of a tensile stress. This mechanism might also be operative in the rhodium-platinum system, where Raub (4) has postulated by analogy the existence of a miscibility gap.

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References

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