Properties of Iridium at High Temperatures

RESISTANCE TO CREEP AND OXIDATION

The outstanding mechanical properties of iridium cannot be fully utilised in air at high temperatures because of the rapid oxidation that occurs. Following his investigations on rhodium (1) Dr Reinacher of Degussa has recently attempted to achieve for iridium some measure of oxidation resistance by using an impermeable platinum sheath (2). Although this expedient was not completely effective, some of his results are worthy of closer attention.

Hot tensile and creep tests were made on 1.5 mm square wires which had been hot rolled from melted and cast ingots. By application at a suitable stage of the hot working procedure, platinum sheathings were put on which yielded 25 and 100 micron layers on the finished product. Although not specifically mentioned in the paper, the photomicrographs illustrated that the platinum sheathing had the curious effect of inhibiting grain growth in the iridium. After comparable degrees of hot work followed by annealing at 1400°C the grain size of the iridium with a 100 micron layer of platinum was one-tenth that of the bare iridium and one-quarter that of the iridium with a 25 micron platinum layer.

Hot Tensile Testing

Up to 500°C the sheathed iridium was stronger than the bare metal. At higher temperatures it was considerably weaker, being, up to 800°C, comparable in strength to unsheathed rhodium. Like rhodium in the earlier work (1) sheathed iridium exhibited a peak tensile strength at 100°C. Unlike rhodium, however, bare iridium did not exhibit this effect, but became progressively weaker as the temperature increased above ambient. At all temperatures up to 1500°C sheathed iridium wires were more ductile than the bare metal, intercrystalline failure being completely inhibited.

Mordike's (3) hot tensile tests were made on work-hardened iridium and he reported much higher tensile strengths and very much lower elongations than Reinacher. At 1400°C, however, the two sets of results coincide, suggesting that this temperature is required to eliminate the effects of cold working. Mordike's tests were made on bare metal. Although tested in vacuum the failures were intergranular, and it might well be that the improved ductility conferred on iridium by a platinum sheath is not completely attributable to minimised oxygen penetration.

Creep Test Results

Under test conditions that exposed the specimens to air at high temperatures for periods up to one hundred hours, sheathed iridium was very much stronger than sheathed rhodium. At 1500°C, for example, iridium with a 25 micron sheath withstood a stress of 7100 p.s.i. for five hours before fracture, while sheathed rhodium at 1250°C failed after the same period at half this stress. The platinum sheath exercised its function for short periods only and the stress/time to rupture curves declined rapidly after twenty hours. This decline was less rapid with the thicker sheath. It is perhaps unfair to judge these materials by the standards applicable to conventional engineering design. The improvements conferred by platinum sheathing, although transient, would undoubtedly be considered valuable in certain advanced applications where a complete equipment might have a working life of a few hours only.

Creep Test Results on Iridium, Rhodium and Platinum Tested in Air				
Specimen	Temperature °C	Stress for instantaneous failure p.s.i. (f_o)	Stress for 100 hour life p.s.i. (f_{100})	$\frac{f_{100}}{f_o}$
25 μ sheathed Ir		16,784	1,840	0.11
100 μ sheathed Ir	1500	12,445		
50 μ sheathed Rh		4,267	825	0.19
Pure Platinum		1,337		
25 μ sheathed Ir		25,320	5,405	0.21
100 μ sheathed Ir	1250	17,420	7,681	0.44
50 μ sheathed Rh		8,534	1,920	0.22
Pure platinum		1,991	554	0.28

Oxidation Effects

Although interdiffusion between the iridium and platinum occurred at high temperatures, rapid oxidation of the iridium inside the sheath tended to prevent complete disappearance of the platinum. After several hours at temperature the grain boundaries of the platinum tended to crack open, probably because of oxygen attack upon the iridium they had dissolved. These cracks allowed free access of air to the iridium core which was rapidly volatilised. At high stresses the grain boundaries pulled apart with no evidence of ductility. At low stresses the solid iridium core became much reduced in diameter. It was surrounded by a coral-like tracery of iridium fronds supported by, or supporting on their outer extremities, a loosely adherent cracked platinum sheath.

This simple expedient of platinum sheathing has given Reinacher results which tend to suggest that the intercrystalline failure of iridium is largely attributable to oxygen attack. Mordike, however, reported intercrystalline failure in vacuum. These conflicting results might be attributable to stress relief by the platinum at the iridium grain boundary, to differences in strain rates, or to the pressure of carbon vapour in Mordike's furnace. The remarkable grain refining effect of the platinum sheathing should not be ignored, and the interesting anomalies arising from Reinacher's and Mordike's results indicate considerable scope for some further investigation.

A.S.D.

References

1 G. Reinacher, *Metall*, 1963, **17**, 699-703
2 G. Reinacher, *Metall*, 1964, **18**, 731-740
3 B. L. Mordike and C. A. Brookes, *Platinum Metals Rev.*, 1960, **4**, 94-99

Influence of Purity on the Work-hardening of Platinum

A comprehensive study of the work-hardening, recovery and recrystallisation of three grades of platinum has been reported by Dr Ernst Raub, of the Forschungsinstitut für Edelmetalle (*Z. Metallkunde*, 1964, **55**, (9), 512). Data were obtained for technically pure (> 99.5 per cent purity), chemically pure (> 99.9 per cent) and physically pure platinum (> 99.99 per cent) after various cycles of cold working and annealing.

Physically pure platinum began to recover after heavy cold working at about 200°C, and recovered rapidly at 250°C. The temperature ranges of recovery and recrystallisation were found to rise with increasing impurity content. Strength at elevated temperatures was increased at higher impurity levels, independently of microstructure and grain size.