New Dispersion Strengthened Platinum Alloy

LOWER RHODIUM CONTENT OFFERS ECONOMIC ADVANTAGES

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Zirconia grain stabilised platinum alloys developed by Johnson Matthey are widely used to contain molten glass. The high temperature strength of these alloys is well in excess of that of similar conventional rhodium-platinum alloys, and zirconia grain stabilised ten per cent rhodium-platinum, the strongest alloy in the range, is used in the most demanding applications where its excellent creep resistance offers prolonged component life. However the present high cost of rhodium, compared with that of platinum, has generated increased interest in alloys with a lower rhodium content suitable for certain applications where the outstanding properties of the ten per cent alloy are not fully utilised. To meet this demand Johnson Matthey have now developed zirconia grain stabilised five per cent rhodium-platinum. This alloy offers a useful range of physical properties for applications where economic considerations are a major factor.

Molten glass is one of the most corrosive materials known to man. However platinum and certain of its alloys have excelled as materials used for the manufacture of apparatus for handling molten glass, primarily because of their unique chemical inertness. This property separates them from all other "corrosion resistant" alloys, and consequently the relatively low strength of conventional platinum alloys at molten glass temperatures was tolerated, and compensated for by careful design including the use of refractory supports. When Johnson Matthey introduced zirconia grain stabilised (ZGS) platinum and platinum alloys their higher strengths and improved creep resistance increased considerably the range of possible applications.

Johnson Matthey manufacture three ZGS materials in significant volume, these being ZGS platinum, ZGS 10 per cent rhodium-platinum and ZGS 5 per cent gold-platinum. All are strengthened by the incorporation of a fine dispersion of zirconium oxide within the metal/alloy matrix. The effect of this oxide is to reduce the rate of grain boundary movement, resulting in the retention of the fibrous microstructure produced during fabrication. High temperature strength and creep resistance are significantly improved by the retention of this highly aligned grain structure, even after a prolonged period at high temperature. Thus component life is increased, or alternatively it may be manufactured from thinner sectioned materials; in either case a considerable cost advantage occurs (1, 2).

The strongest alloy in the ZGS range is ZGS 10 per cent rhodium-platinum. This is widely used as a constructional material throughout the glass manufacturing industry, and especially for baseplates for glass fibre bushings. The rhodium acts as a solid solution strengthener giving superior creep resistance to that of ZGS platinum, which in turn has greater creep resistance than all the conventional alloys up to

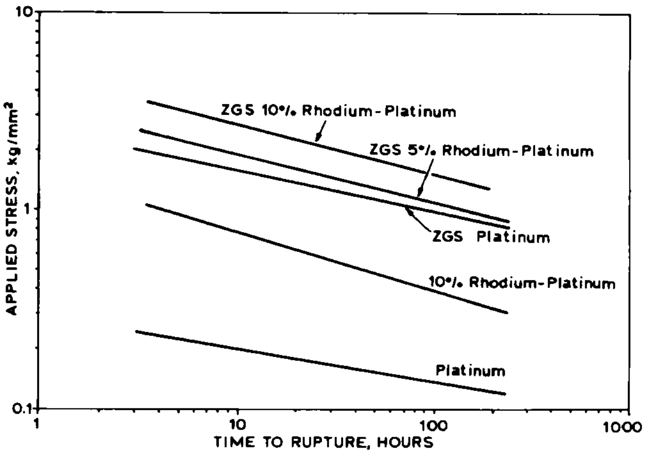

Fig. 1 The stress rupture properties at 1400°C of the new ZGS 5 per cent rhodium-platinum alloy lie between those of ZGS platinum and ZGS 10 per cent rhodium-platinum. For comparison the properties of conventional platinum and 10 per cent rhodium-platinum are also included

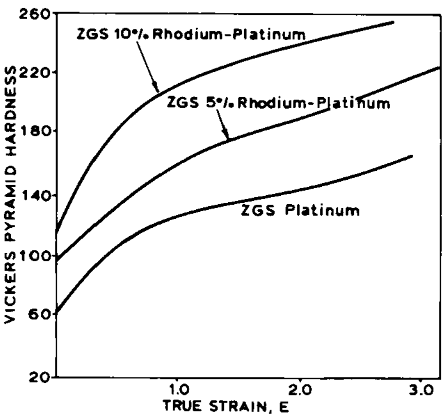

Fig. 2 Plotting true strain against hardness shows that the work hardening characteristics of ZGS 5 per cent rhodium-platinum are also between those of ZGS platinum and ZGS 10 per cent rhodium-platinum

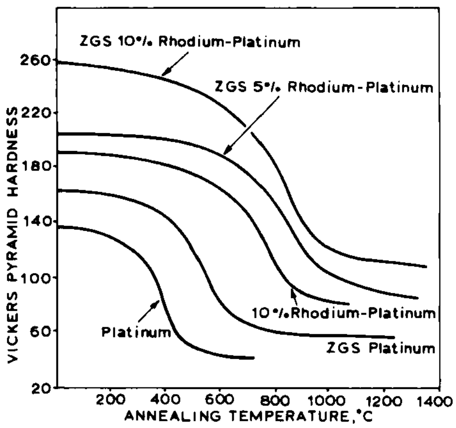

Fig. 3 Recrystallisation curves are shown for both conventional and zirconia grain stabilised platinum, and some of its alloys. The test samples were held at the annealing temperatures for 30 minutes

and including 40 per cent rhodium-platinum. In addition rhodium increases the wetting angle of molten glass in contact with the alloy, which is advantageous when high quality glass is being manufactured (3).

The recent rise in the price of rhodium, however, has resulted in a demand for high strength alloys of lower rhodium content. As an alternative to ZGS 10 per cent rhodium-platinum Johnson Matthey have developed ZGS 5 per cent rhodium-platinum, a cheaper alloy which none the less is more resistant to creep than ZGS platinum.

Some Properties of ZGS 5 per cent Rhodium-Platinum

The manufacturing process used to produce ZGS 5 per cent rhodium-platinum is essentially that used for the current range of ZGS alloys, thus its physical and mechanical properties lie between those of ZGS platinum and ZGS 10 per cent rhodium-platinum.

Fig. 4 The fibrous structure of ZGS 5 per cent rhodium-platinum is retained after annealing at 1100°C, following cold working to a 90 per cent reduction in cross-sectional area ×150

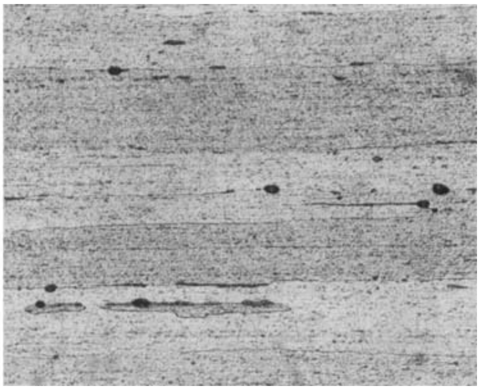

Fig 5. Metallographic examination shows that even after prolonged heat treatment at 1400°C ZGS 5 per cent rhodium-platinum retains a fibrous grain structure ×150

The comparison is shown in the Table, where the properties of some conventional rhodium-platinum alloys are also included. For glass manufacture one of the most significant properties is the high temperature strength and in this respect it can be seen that, although not matching the excellent creep resistance of ZGS 10 per cent rhodium-platinum, ZGS 5 per cent rhodium-platinum offers considerable improvement over both ZGS platinum and the strongest conventional rhodium-platinum alloy, namely 40 per cent rhodium-platinum. This is shown in more detail in Figure 1 where the stress-rupture lives of ZGS alloys are plotted against the applied stresses.

The work hardening response and recrystallisation behaviour of the new alloy are illustrated in Figures 2 and 3, respectively, where comparison is again made with the other ZGS alloys. These properties suggest that ZGS 5 per cent rhodium-platinum would fabricate as readily as the other ZGS alloys, and this has been confirmed during development work.

The microstructural behaviour is typical of the ZGS alloys, the zirconia dispersion retaining the fibrous "as worked" structure; this is shown in Figures 4 and 5.

Economic Considerations

In the past twelve months the ratio of the cost of rhodium to that of platinum has fluctuated between 2 : 1 and 4 : 1. In the medium term it

Properties of Selected Platinum Based and ZGS Platinum Based Alloys

	Conventional			Zirconia Grain Stabilised		
	Pt	10% Rh-Pt	40% Rh-Pt	Pt	5% Rh-Pt	10% Rh-Pt
Specific gravity, g/cm³ (at 20°C)	21.4	20.0	16.8	21.4	20.6	20.0
Hardness, Hv (annealed)	40	75	115	60	95	110
UTS, kg/mm² (annealed)	12.7	33.8	57.5	18.6	29.2	36.2
Elongation, per cent (annealed)	40	35	30	42	24	30
100 hour Stress rupture life, kg/mm² (at 1400°C)	0.14	0.36	0.69	0.91	1.05	1.41

seems probable that the price differential existing between these two elements will be maintained. Thus the basic material cost of rhodium-platinum alloys is considerably influenced by the rhodium content. Every 5 per cent rhodium addition to platinum increases the cost of the alloy by approximately 10 per cent. For those who use large amounts of rhodium-platinum alloys, such as the manufacturers of high quality glass, the cost savings that can be made by using alloys of lower rhodium content, wherever possible, are significant.

By retaining many of the virtues of the higher rhodium content alloy, ZGS 5 per cent rhodium-platinum offers an attractive economic alternative to ZGS 10 per cent rhodium-platinum.

References

1 G. L. Selman, J. G. Day and A. A. Bourne, *Platinum Metals Rev.*, 1974, **18**, (2), 46

2 G. L. Selman and A. A. Bourne, *Platinum Metals Rev.*, 1976, **20**, (3), 86

3 G. L. Selman, M. R. Spender and A. S. Darling, *Platinum Metals Rev.*, 1965, **9**, (3), 92; 1965, **9**, (4), 130; *ibid.*, 1966, **10**, (2), 54

Commodity Meeting on the Platinum Metals

A SURVEY FOR THE INSTITUTION OF MINING AND METALLURGY

For some years the Institution of Mining and Metallurgy has organised an annual "Commodity Meeting" to discuss the whole background to a particular metal. The eleventh of these conferences, held on 4th December at the Geological Society, was devoted to the platinum group of metals, their history, resources, mining, refining and applications.

After the official opening by the President, Dr. A. J. Robinson, a paper on "Platinum: the History of One of the World's Most Strategic Metals" was presented by Dr. F. D. Collender of Strauss, Turnbull & Co. Outlining the history of its discovery in South America, the first scientific studies of its properties in the eighteenth century and then its more recent developments, the author emphasised how vital platinum has become to meeting man's greatest needs—food, fuel, communications, optics and clothing, playing an essential part in the power, fertiliser, petrochemical, electronics, glass and synthetic fibre and automotive industries.

Professor D. L. Buchanan of the Royal School of Mines described the geology underlying the world's supply of platinum metals, while the investigation of the so-called UG2 reef, below the famous Merensky Reef, was reported by I. M. Hossy and A. A. Saffy.

Recently the control of gaseous pollution of the atmosphere has received greatly increased attention from all quarters, and the development of catalytic procedures, based upon the platinum metals, for this purpose was described by Mr. Colin Jaffray of Johnson Matthey's Catalytic Systems Division. The role of these metals is now crucial in this connection.

The separation and refining of the six platinum metals involves a highly complex series of hydrometallurgical operations and those in use at the Inco refinery were outlined by Dr. B. F. Rimmer. The current flow sheet includes leaching, precipitation, crystallisation, distillation, ion exchange and solvent extraction.

An informative paper, by B. M. Symes, a consulting metallurgist, dealt with the processing of the platinum metals from minerals onwards, particularly those from the primary source in the western world, the Merensky Reef. The older conventional procedure was compared with the newer solvent extraction process. By this route the metals are refined to a high state of purity, normally 99.95 per cent.

Developments in the market for platinum formed the subject of an interesting paper by Mr. Alan Austin, General Manager Platinum Marketing, Johnson Matthey. This emphasised the rather dramatic developments in the range and size of its applications that have taken place over the last thirty-five years and examined the key factors that have influenced the market.

In conclusion trends in the industrial applications of the platinum metals were discussed by Dr. G. J. K. Acres, Director, Corporate Development (Technology), Johnson Matthey. In addition to their established uses and their dependence upon the chemical and physical properties of these metals and their alloys, recent applications have resulted from the use of coatings and dispersions on polymers, base metals and metal oxides. By utilising such combinations significant advances have become possible in applications such as magnetic alloys, catalysis, electronics and cancer chemotherapy.

The full proceedings of this meeting will be published in July in the Transactions of the Institution. L.B.H.