FURTHER DEVELOPMENT OF OXIDE DISPERSION HARDENED PLATINUM ALLOYS WITH IMPROVED STRENGTH AT HIGH TEMPERATURES

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Introduction

The platinum group metals, especially platinum, rhodium and iridium are widely used as high temperature materials, despite the high prices. The reasons for that are the superior properties, especially very good chemical stability, oxidation resistance at high temperatures and stability against molten oxides. These materials can be used at extremely high temperatures near the melting point and have adequate mechanical strength at very high temperatures. For these reasons, the platinum group metals and their alloys are essential as structural materials under severe thermal, chemical and mechanical loadings, for example in glass melting plants [1, 2] as well as in rocket and aerospace technology.

Scientific and technical status

For many applications an increase in strength of the platinum materials is necessary. In the first place, this is possible by solid solution strengthening. To minimize the weight of the structure, a further increase in strength is necessary. This is possible by oxide dispersion strengthening. ODS platinum materials have already been used for a fairly long time. However, most ODS platinum materials show considerable disadvantages. Problems occur in processing, especially in welding [2]. The oxide particles coagulate and float to the surface in the fusion zone, resulting in a substantial decrease in strength. Furthermore, some materials show a tendency to brittleness, are sensitive to cracking and the manufacturing is complex.

More than ten years ago, the company W. C. Heraeus GmbH in Hanau, Germany and the University of Applied Sciences Jena, Germany developed a new class of ODS platinum materials with excellent properties. These are the Pt DPH materials [2].
They have excellent properties, as well as good weldability and ductility. The Pt DPH materials are being used very successfully in industry, especially in glass melting equipment for high temperatures [2-4].

Experimental

Development of Pt DPH materials
A completely new process was developed for the production of the Pt DPH materials. Oxidizable additions of metals such as zirconium, yttrium, scandium and cerium are added to the platinum in elemental form during the melting process. The alloy is cast to conventional ingots. During the subsequent forming operations, the semi-finished products (typically sheets, tubes and rods) are subjected to an annealing process in an oxidizing medium which leads to the internal oxidation of the platinum material. The internal oxidation leads to the formation of finely dispersed oxide precipitates from the alloying addition elements. Moreover the duration of the annealing process is adjusted to ensure that the reactive elements are essentially fully converted to oxides.

Further development of Pt DPH materials with improved strength
The better strength is achieved by higher contents of oxide dispersoids (Zr-Y-Sc mixed oxide with app. 4,000 ppm Zr). Despite its much higher strength the material can be rolled readily to thin sheets and processed to seamless tubes. A further increase in strength can be obtained by thermo-mechanical treatment.

Equipment for measuring mechanical properties
The stress-rupture strength, the creep behaviour and the hot tensile strength of high-melting metals (Pt materials, Rh, Ir, Mo, Re, W and their alloys) can be measured in test facilities that have been specially developed and built at the University of Applied Sciences Jena. This equipment permits measurements up to 3,000°C either in air or under a protective gas atmosphere [2]. The samples were investigated using metallography, SEM, TEM and SSIMS (scanning secondary ion mass spectroscopy).

Results

Figure 1 shows the element distribution as determined on Pt DPH with SSIMS. The elements zirconium, yttrium, scandium and oxygen are present at the same places, both in the grain boundaries and in the precipitate particles in the matrix. It is therefore a mixed oxide of Zr-Y-Sc.
The stress-rupture strength of the new materials Pt-10%Rh DPH*hs* and Pt-10%Rh DPH*hs plus* are compared with the established material Pt-10%Rh DPH at 1,600 °C (see figure 2). Pt-10%Rh DPH*hs* has a improved stress-rupture strength, as a result of the higher contents of oxide dispersoids. A further significant increase in strength was achieved by thermo-mechanical treatment of the material Pt-10%Rh DPH*hs plus*. Figure 3 shows the

Norton creep law for the same range of platinum materials. In agreement with the higher strength the Norton plot shows lower creep rates for the new *hs*- and *hs plus*- qualities than for the established material. Figure 4 shows the higher tensile strength of Pt-10%Rh DPH*hs* in comparison to the established material.
The newly developed materials have already been implemented into the production. First components made of the new Pt DPH materials have been proved in the glass industry under high mechanical load.

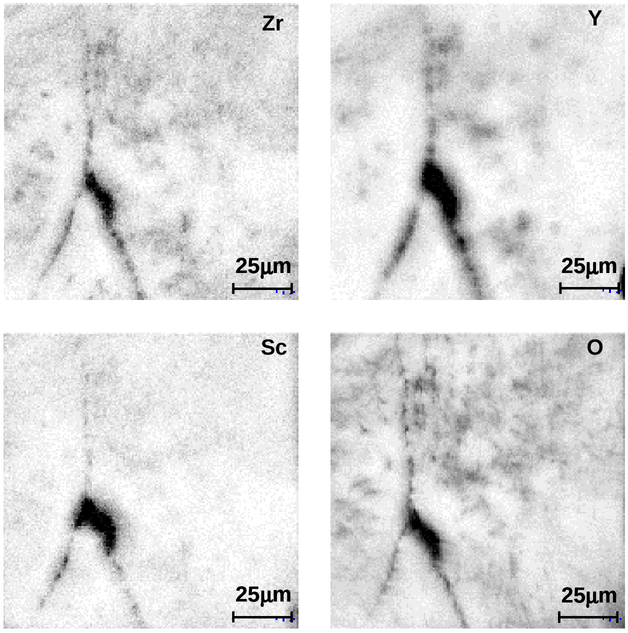

Fig.1: Scanning SIMS micrographs showing the distribution of various elements in Pt-10%Rh DPH*hs*

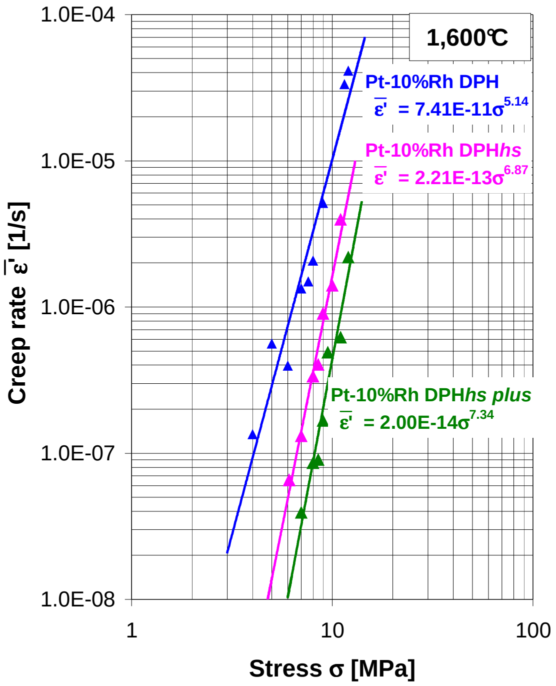

Fig. 3: Norton Plot of Platinum DPH materials

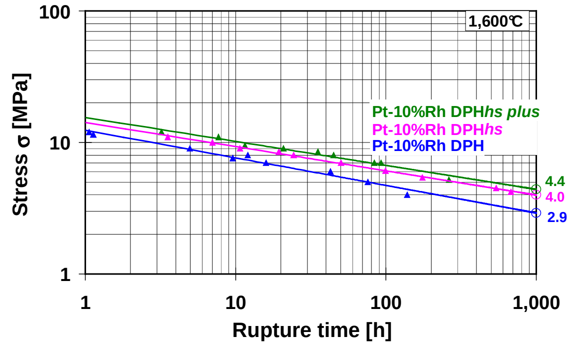

Fig. 2: Stress-rupture curves of Platinum DPH materials

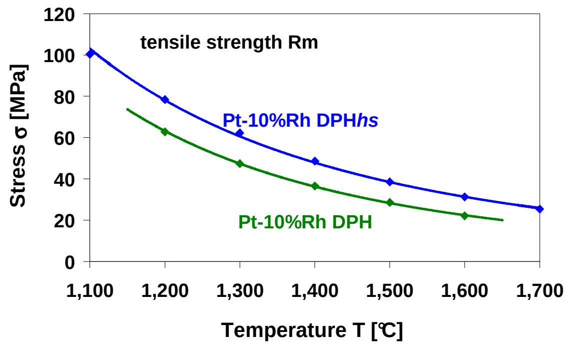

Fig. 4: High temperature tensile strength of new Pt-10%Rh DPH*hs* and established Pt-10%Rh DPH at various temperatures

References

1) D. Lupton, J. Merker, B. Fischer, R. Völkl Platinum Materials for the Glass Industry, 24th IPMI Conf., Williamsburg, Virginia, USA, (2000).

2) B. Fischer et al. Practical Experience with New Oxide Dispersion Hardened Platinum Materials, 25th IPMI Conf., Tucson, Arizona, USA, (2001).

3) B. Fischer, D. Freund, R. Völkl, D. Lupton Oxide Dispersion Hardened Platinum Materials for High Temperature Applications, Thermec, Las Vegas, Nevada, USA, (2000).

4) Pt-5%Rh DPH – an ODS Platinum Material with excellent properties for high temperature Applications, 31st IPMI Conf., Miami, Florida, USA, (2007)