OPTIMISATION OF COMPOSITIONS AND HEAT TREATMENTS OF Pt-BASED SUPERALLOYS

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Nickel-based superalloys are constrained by the melting point of Ni for increased higher temperature uses, and Pt is a candidate for replacement[1]. Several experimental Pt-based alloys have been studied at Mintek. The best properties were exhibited by the Pt-Al-Cr and Pt-Al-Ru alloys which had ~Pt_3Al precipitates in a (Pt) matrix. However, the precipitate volume fraction was not as high as in the Ni-based superalloys. Ternary alloys were combined, and the Pt_{84}:Al_{11}:Ru_2:Cr_3 alloy is the optimum composition so far[2], but the volume fraction still needs improvement. Thus, this work is an investigation to increase the ~Pt_3Al volume fraction in Pt-Al-Ru-Cr alloys, by varying compositions and heat treatments.

Six alloys of different compositions were selected using the optimum composition as the basis. The nominal compositions of these alloys are given in Table 1. Alloys were prepared by arc-melting pure (at least 99.9%) elements together. The samples were then sectioned, and one half was heat treated in air at 1500°C for 18 hours and quenched in water, followed by homogenization heat treatment at 1100°C for 120 hours and air cooling. Metallographic preparation was undertaken, finishing with an oxide polishing (OP-S) technique. Microstructural analyses were carried out in an HR FEI Nova NanoSEM in the BSE mode, also using EDX. XRD was done for confirmation of the (Pt) and ~Pt_3Al phases.

Typical examples of the microstructures in both the as-cast and heat treated conditions are shown in Figs. 1 and 2 for Pt_{85}:Al_7:Ru_3:Cr_5. The as-cast alloy (Fig. 1) had (Pt) dendrites with fine ~Pt_3Al precipitates, surrounded by a mixture of (Pt) + ~Pt_3Al. The mixture was deduced to arise from the eutectoid reaction, since (Pt) was crystallographically aligned. The heat treated sample had ~Pt_3Al precipitates in a (Pt) matrix. In all samples, the precipitates were spherical rather than cuboid. The average precipitate size was below 1 µm. The ~Pt_3Al volume fraction was observed to increase with increasing Pt:Al ratios. By visual examination, Pt_{85}:Al_7:Ru_3:Cr_5 had a high volume fraction of the ~Pt_3Al precipitates, although confirmatory measurements by image analysis still needs to be done.

EDX phase analyses were also carried out on all samples. Table 2 shows the EDX analyses of Pt_{85}:Al_7:Ru_3:Cr_5. The partitioning behaviour of elements in the phases in both conditions of the sample was similar. X-ray diffraction confirmed the presence of (Pt) and ~Pt_3Al.

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References:
1. Wolff, I.M. & Hill, P.J. (2000) Platinum Metals Rev., 44, 158.
2. Cornish, L.A. *et al.* (2007) J. South Afr. Inst. Min. & Met., 107, 697.

Table 1. Nominal alloy compositions (at.%).

Alloy no.	Pt	Al	Ru	Cr
1	78	15.5	2	4.5
2	80	14	3	3
3	81.5	11.5	2.5	4.5
4	82	12	2	4
5	84	11	2	3
6	85	7	3	5

Table 2. EDX phase analysis compositions (at.%).

	As-cast		Heat treated	
	(Pt)	(Pt) + ~Pt_3Al	(Pt)	~Pt_3Al
Pt	90.4±0.5	84.3±0.2	89.1±0.4	83.4±0.2
Al	2.9±0.3	13.7±0.1	5.3±0.4	14.1±0.2
Cr	4.9±0.2	1.4±0.3	4.1±0.1	1.8±0.1
Ru	1.8±0.4	0.6±0.2	1.5±0.1	0.7±0.2

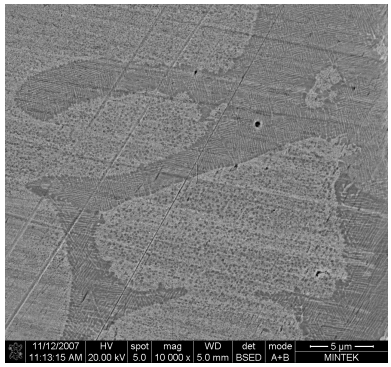

Figure 1. BSE image of as-cast Pt_{85}:Al_7:Ru_3:Cr_5: (Pt) dendrites (light) with eutectic (Pt) + ~Pt_3Al (dark).

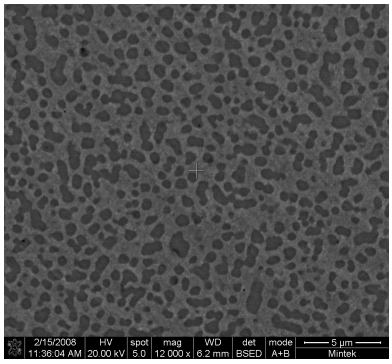

Figure 2. BSE image of heat treated Pt_{85}:Al_7:Ru_3:Cr_5: ~Pt_3Al precipitates (dark) in a (Pt) matrix (light).

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