A systematic study of the effect of the nickel and cobalt respective proportions in M–30Cr alloys (M = Ni and/or Co) on their behavior in oxidation at high temperature

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Nickel and cobalt are frequently present together in cast superalloys. For instance nickel is almost systematically present in the chemical composition of cobalt alloys to help the austenitic structure to remain stable despite the temperature variations which may occur in service. It is often observed that the oxidation behavior at high temperature is better in great presence of nickel than in great presence of cobalt. The aim of this study is to explore the effect of the Co/Ni ratio on the oxidation behavior in the case of simple cast alloys composed of nickel, cobalt and chromium only, and elaborated following exactly the same procedure. Thermogravimetric tests were carried out in air at 1200°C, followed by post-mortem characterization of the oxidized samples (XRD, SEM, EDS).

A series of six (70-x)Co–30Cr; 0 ≤ x ≤ 70) alloys were elaborated by conventional foundry. First, the obtained general chemical compositions were controlled by energy dispersive spectrometry. Second, thermogravimetric tests at 1200°C were performed, followed by the exploitation of the mass gain files to access to the oxidation kinetics. Post-mortem characterization was carried out for knowing the natures and quantities of the oxides formed and the subsurface changes induced by oxidation.

Summary / Conclusions

• In fact, in the case of these binary and ternary alloys, the mass gain kinetics as well as the oxide spallation at cooling remain all rather similar to one another, although the maximal amplitude of the (Ni by Co) replacement; obviously, if they really exist, the differences between the cobalt–based alloys and the nickel–based alloys stay inconspicuous during the four first tens of hours in air at 1200°C.

• In contrast, significant differences are evidenced by the Cr concentration profiles: when more and more cobalt comes substituting nickel, the minimal Cr content decreases and becomes closer and closer to critical values, while the Cr gradient value increases; for similar final mass gain rates this means that the diffusion coefficient decreases with the Co addition.

• Much more visible differences are expected for longer times, since the Co–richest alloys will certainly fall soon in a catastrophic oxidation while the Ni–richest can stay chromia–forming.