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Kinetic of oxidation at 1000, 1100 and 1200°C of 32.5wt.%Cr-containing Co-based alloys reinforced by hafnium carbides

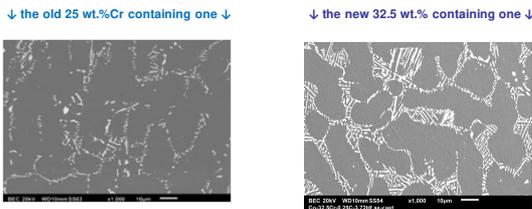
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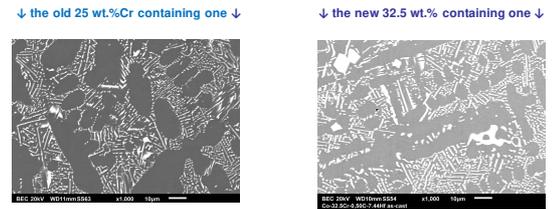
Many cobalt-based superalloys and some nickel-based ones are reinforced by interdendritic carbides for allowing to use them in hot conditions [1]. Such carbides must be stable enough at high temperature in term of geometry/shape as well in term of volume fraction. The TaC carbides which reinforce some cobalt-based alloys do not rapidly evolve while TaC carbides are much less stable in chromium-rich nickel-based alloys (and even less stable than the chromium carbides in this second family of alloys [2]). HfC are among the carbides which are more stable at high temperature than the tantalum carbides, much more in the case of the nickel-based alloys [3] and already a little more in the case of the cobalt-based ones [4,5]. Hafnium carbides may potentially lead to nickel-based and cobalt-based alloys very resistant against creep deformation at high temperature but it was recently found that the HfC carbides network may be rather neutral for the behaviour of the nickel-based alloys in oxidation at high temperature [6], but detrimental for the alloys which are based on cobalt [7]. The good stability of the HfC carbides in the same families of alloys can be also exploited at lower temperatures such as 1100 and 1000°C. It appeared that it can be interesting to characterize the behaviour in oxidation at these temperatures of the same alloys already studied at 1200°C [6,7], in order to see if the behaviour of the cobalt-based alloys notably is improved 100°C or 200°C lower. Thus several new alloys with the same carbon (0.25 and 0.50 wt.%) and hafnium (3.7 to 7.4 wt.%) contents as the alloys previously studied at 1200°C were elaborated by foundry and tested in oxidation at 1100°C and 1000°C. The final mass gains, natures of oxides present externally and the values of parabolic constant and chromia volatilization constant (both extracted from the mass gain versus time file according to the $\{m \times dm/dt = K_p - K_v \times m\}$ method [8]), clearly show that the behaviour of these alloys are really better, especially in the case of the cobalt alloys.

As-cast microstructures of the {0.25 wt.%C, 3.72 wt.%Hf}-containing alloys

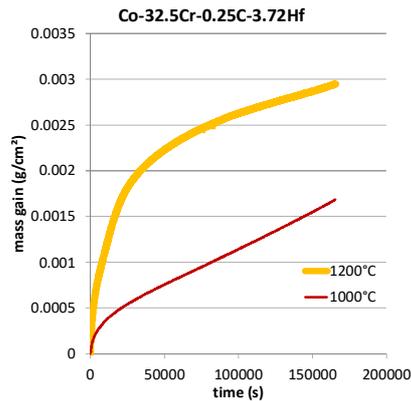


32.5 wt.% Cr instead 25 wt.%.
no significant changes in the microstructures

As-cast microstructures of the {0.50 wt.%C, 7.44 wt.%Hf}-containing alloys

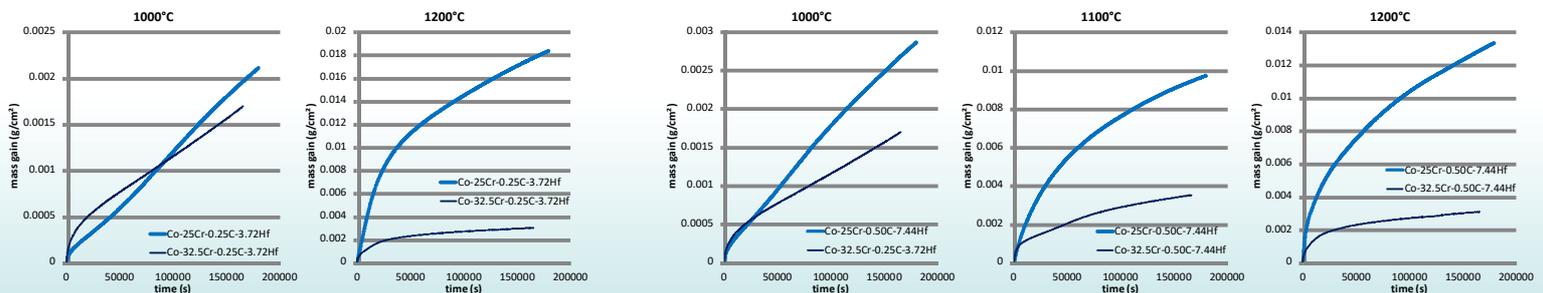
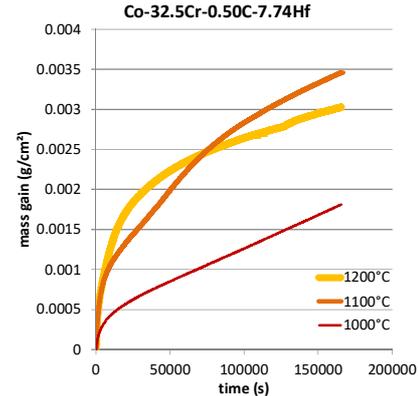


but major improvement of the resistance against high temperature oxidation!



0.25 wt.%C 25 wt.%Cr		0.25 wt.%C 32.5 wt.%Cr	
$10^{12} \times K_p$ (g ² cm ⁴ s ⁻¹)	$10^{10} \times K_v$ (g cm ² s ⁻¹)	$10^{12} \times K_p$ (g ² cm ⁴ s ⁻¹)	$10^{10} \times K_v$ (g cm ² s ⁻¹)
1200°C	2510	249	506
1000°C	2.5*	9.1	56
0.50 wt.%C 25 wt.%Cr		0.50 wt.%C 32.5 wt.%Cr	
$10^{12} \times K_p$ (g ² cm ⁴ s ⁻¹)	$10^{10} \times K_v$ (g cm ² s ⁻¹)	$10^{12} \times K_p$ (g ² cm ⁴ s ⁻¹)	$10^{10} \times K_v$ (g cm ² s ⁻¹)
1200°C	1330	118	326
1100°C	470	85	161
1000°C	8.9*	7.7*	9.0*

*: only during less than 10 hours; after linear and fast



When the chromium content of these alloys is 7.5 wt.% higher, the microstructures are not significantly changed. They even tend to be more rich in HfC carbides, which is potentially better for their high temperature mechanical properties. In the field of the oxidation behavior at high temperature this increase in chromium content greatly improves the resistance of the alloys. The mass gain rates are much lower and the kinetics are more often parabolic than for the later alloys which tend to linearly oxidize.

Rather slow and parabolic kinetics seems showing that these HfC-reinforced cobalt-based alloys behave as chromia-former ones. X-ray diffraction runs and metallographic characterization are on going to verify this hypothesis. It is possible that additional increase in chromium content is still compulsory to ensure reproducible chromia-forming behavior in order to benefit on long times of the superior creep-resistance of such alloys at high temperature. Rather than Cr-increase of the bulk Cr-deposition by pack-cementation for instance may be preferable to do not risk the appearance of brittle TCP phases.

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