



Effect of the presence of water vapour on the high temperature oxidation of Co-10Ni-30Cr and Co-10Ni-30Cr-0.5C alloys. Part 1: Results in oxidation in dry air

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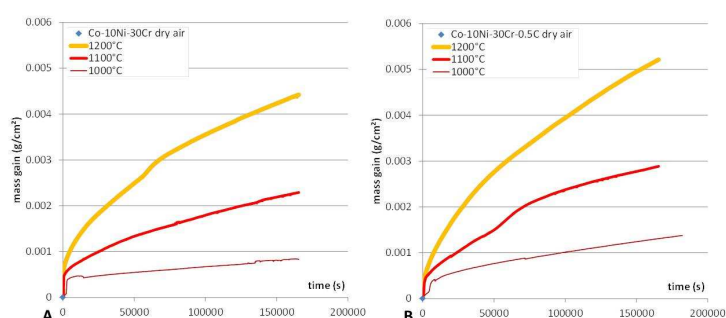
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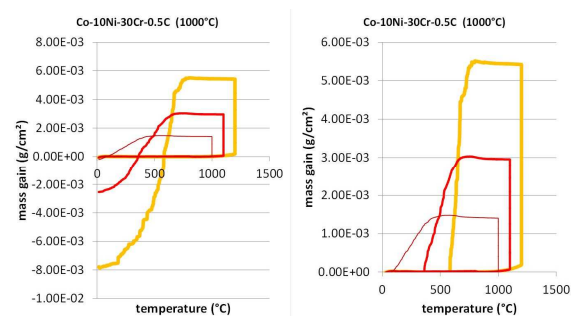
Water vapour is known to influence the general behaviour of refractory alloys and superalloys in oxidation at high temperature [1], in terms of isothermal oxidation rate, volatilization of the protective scale formed (alumina, chromia or silica), and of oxide scale spallation in thermal cycling. After having studied the double kinetic of both mass gain of oxidation and mass loss by chromia volatilization in the case of chromia-forming nickel-based alloys [2], it was wished here to characterize the effect on oxidation of water vapour in the case of cobalt alloys, with thermogravimetry recording followed, here too by using the $(m \times dm/dt = K_p - K_v \times m)$ method [3] for the isothermal part, and by examining their heating and cooling parts.

Cobalt-based superalloys are generally rich in chromium (several tens weight percents) and are strengthened by carbides. Many of them additionally contain several weight percents of nickel to stabilize the FCC network of the matrix. These are the reasons why the two simple model alloys considered in this work are: first a carbide-free Co-10Ni-30Cr ternary alloy to study the specific behaviour of the matrix, and second a Co-10Ni-30Cr-0.5C to examine the case of the same alloy but containing significant fraction in chromium carbides.

These two alloys were elaborated by high frequency induction melting from pure elements, in inert gas. The parallelepiped samples were cut and ground with smoothing of edges and corners, then subjected to thermogravimetry runs performed in dry synthetic air and in humidified air (temperatures of test: 1000, 1100 and 1200°C, duration: 50 hours. The analysis of the three parts (heating, isothermal oxidation, cooling) of the mass gain files, as well as the post-mortem metallographic characterization of the oxidized samples, will allow evidencing the effect of water vapour on numerous characteristics of the high temperature oxidation of these cobalt-based alloys. In this first part only the results of oxidation in dry air will be presented.

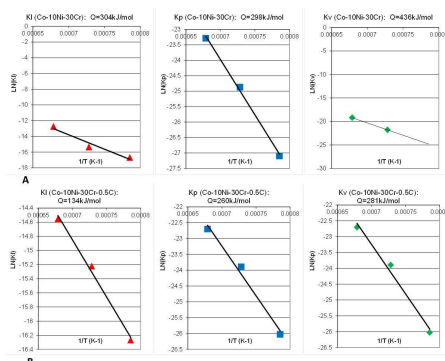


The thermogravimetry curves obtained for the Co-10Ni-30Cr (A) and Co-10Ni-30Cr-0.5C (B) alloy at 1000, 1100 and 1200°C in dry air

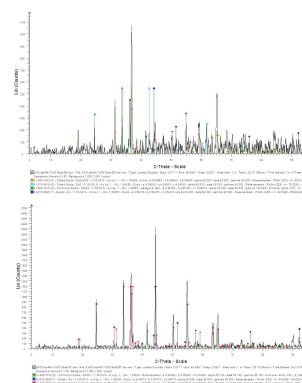
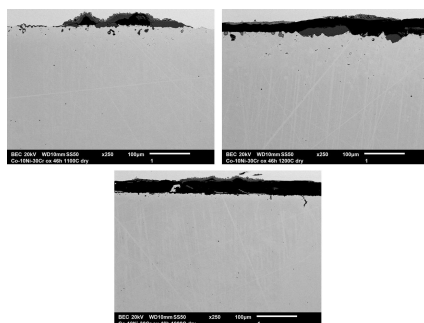


The mass variations plotted versus temperature after correction from the air buoyancy variation; visualization of the start of oxidation at heating on and of the oxide spallation at cooling

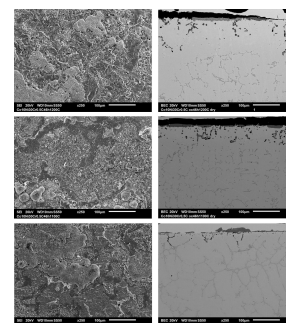
The values of K_I (linear constant at the beginning of the isothermal stage), of K_p and of K_v (parabolic constant and chromia volatilization constant issued from the $m \times dm/dt = f(m)$ treatment [3]) obtained for the Co-10Ni-30Cr (A) and Co-10Ni-30Cr-0.5C (B) alloys, plotted in the Arrhenius scheme; values of the activation energies (Q)



Cross-sectional SEMBSE micrographs illustrating the oxidized surfaces of the Co-10Ni-30Cr alloy after 46h at 1000°C (bottom), 1100°C (top, left) and 1200°C (top, right)



The XRD patterns obtained on the oxidized surfaces of the Co-10Ni-30Cr (top) and Co-10Ni-30Cr-0.5C (bottom) after oxidation test at 1100°C



Surface SEM/SE (left) and cross-sectional SEMBSE (right) micrographs of the oxidized states of the Co-10Ni-30Cr-0.5C alloy after 46h at 1000 (bottom), 1100 (middle) and 1200°C (top)

With these two simple alloys, typical of many of commercial cast cobalt-based alloys and their 10 wt.%Ni for austenite stabilizing and their 30 wt.%Cr, and 0.5 wt.%C for the second alloy, this characterization of their high temperature oxidation behaviour will be used for comparison basis for the same alloys but oxidizing in wet air. Differences concerning the start of oxidation and the rates of mass gain, but also the rate of chromia volatilization and the effect on scales spallation at cooling or during thermal cycling oxide adherence will be particularly expected. This is what will be discovered in the second part of this work.

References

- [1] Young, D., High Temperature Oxidation and Corrosion of Metals, Elsevier Corrosion Series (Amsterdam, 2008).
- [2] Berthod, P., Aranda, L., Mathieu, S., Vilasi, M., "Influence of water vapour on the rate of oxidation of a Ni-25wt.%Cr alloy at high temperature", Oxidation of Metals, Vol. 79, No. 3-4 (2013), pp. 517-527.
- [3] Berthod, P., "Kinetics of high temperature oxidation and chromia volatilization for a binary Ni-Cr alloy", Oxidation of Metals, Vol. 64, No. 3-4 (2005), pp. 235-252.