

# Effect of the presence of water vapour on the high temperature oxidation of a Co-10Ni-30Cr alloy. Part 2: Kinetic results in oxidation in wet air and comparison with dry air

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Faculté des Sciences et

Technologies

### Effect of the presence of water vapour on the high temperature oxidation of a Co-10Ni-30Cr alloy. Part 2: Kinetic results in oxidation in wet air and comparison with dry air

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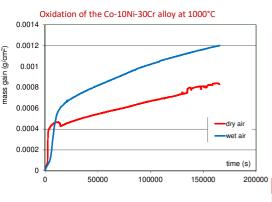


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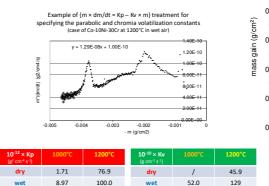
Water vapour is known to influence the general behaviour of superalloys in oxidation at high temperature [1], in terms of isothermal oxidation rate, volatilization of the protective scale formed (alumina, chromia or silica), and of oxide scale spallation in thermal cycling. After having studied the double kinetic of both mass gain of oxidation and mass loss by chromia volatilization in the case of chromia-forming nickel-based alloys [2,3], 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 x dm/dt = Kp - Kv x m} method [4] for the isothermal part, and by examining their heating and cooling parts.

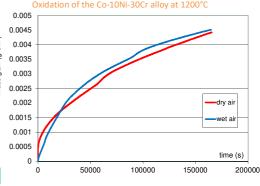
Cobalt-based superalloys are generally rich in chromium (several tens weight percents) and are strengthened by carbides [5]. Many of them additionally contain several weight percents in nickel to stabilize the FCC network of the matrix. These were the reasons why a simple model alloy was considered in this work: a carbide-free Co-10Ni-30Cr ternary alloy (study of the specific behaviour of the matrix). This cast alloy was subjected to oxidation in humidified air inside a thermobalance. The results of the analysis of the three parts (heating, isothermal oxidation, cooling) of the mass gain files were compared to the corresponding ones obtained in dry air last year [6] for the same alloy. The results of the metallographic characterization of the oxidized samples will be presented next year [7].

> The Co-10Ni-30Cr alloy (wt.%) was elaborated by high frequency induction melting from pure elements, in inert gas. Parallelepiped samples were prepared and subjected to thermogravimetry runs carried out in humidified air (temperatures of test: synthetic air  $80\%N_2 - 20\%O_2$  with addition of 180mbars  $H_2O$  (air with 90% of relative humidity at 60°C), temperatures: 1000 and 1200°C, duration: 46 hours.



Isothermal mass gain kinetic





#### Scale behaviour at cooling

250

6.00E-03

4.00E-03

2.00E-03

0.00E+00

0.0015

0.001

0.0005

-0.0005

-0.001

-0.0015

-0.002

0

mass gain (g/cm<sup>2</sup>)

Co-10Ni-30Cr oxidized at 1000°C

500

750

temperature (°C)

Co-10Ni-30Cr oxidized at 1200°C

250 500 1000

1250

wet air

-dry air

750 1000 1250

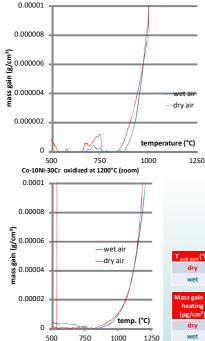
dry air

wet air

temperature (°C

## Co-10Ni-30Cr oxidized at 1000°C (zoom

Oxidation at heating



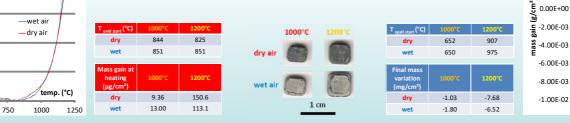
Concerning the isothermal oxidation kinetic, the studied ternary cobalt-based alloy globally follows a parabolic law. The presence of water with this content seems inducing a rather faster oxidation (higher values of the parabolic constant Kp) as well as an accelerated volatilization of chromia (re-oxidation of Cr2O3 into gaseous CrO3 or CrO<sub>2</sub>(OH)<sub>2</sub>) as revealed by the higher values of the volatilization constant Kv.

Water vapour seems also affecting the oxidation during the +20°C/min-heating up to the stage temperature:

\* the mass gain detectable by the thermo-balance is reached at a slightly higher temperature than in dry air.

the total mass gain achieved before reaching the stage also seems depending on the presence of water.

In contrast, and contrarily to what is generally expected when there is significant concentration in water vapour in the oxidizing atmosphere, no real effect was seen, in the case of this ternary cobaltbased alloy, about the adherence of the oxide scale on the substrate and thus about the spallation behaviour at cooling.





[2] [3] vapour rich air", Materials at High Temperature, on-line first:

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[4] [5] [6] [7]