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Influences of the base element and of the density of carbides on the high temperature oxidation behaviour of M-Cr-C alloys

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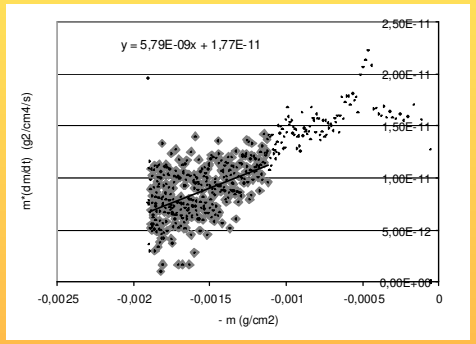
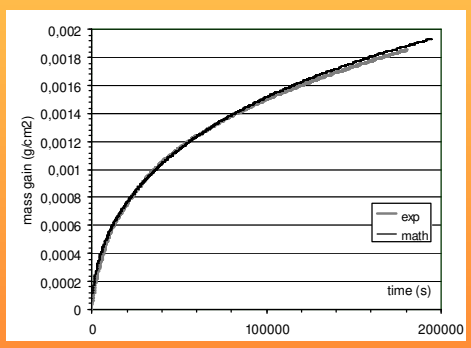
Nickel, iron and cobalt are the main elements used as a base for conventionally cast alloys and superalloys intended for high temperature applications for which a good resistance against oxidation by hot gases is required. In the case of alloys reinforced by carbides the high temperature oxidation behaviour may depend on both the matrix nature and the density of carbides. The aim of this work is to study how the presence and the density of interdendritic chromium carbides can operate to modify - and if possible to improve – the resistance against oxidation of resistant nickel base alloys and less resistant iron and cobalt base alloys.

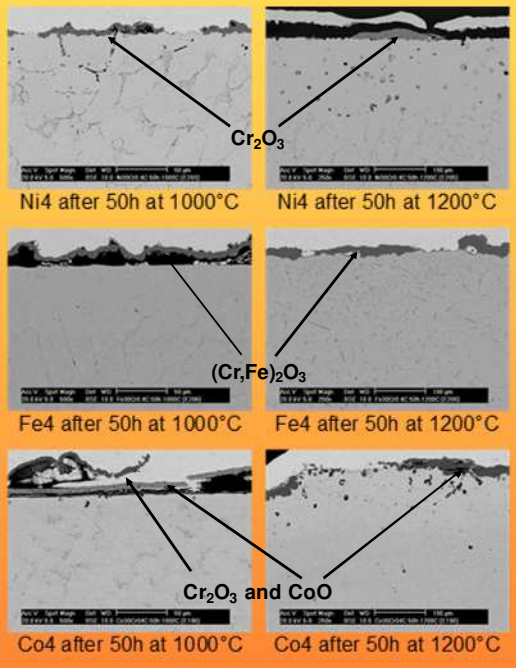
Thermogravimetry runs were performed on cast binary M30Cr and ternary M30CrxC alloys (M = Ni, Co and Fe; x = 0.2, 0.4 and 0.8%wt.) in dry air at 1000, 1100 and 1200°C for 50 hours. Mass gain measures were analyzed according to the {dm/dt = Kp – Kv . m} law in order to get simultaneously the parabolic constant Kp and the chromia-volatilization constant Kv, which were tested by comparison of experimental curve and curve plotted using the determined values. The surfaces of the oxidized alloys were studied using Scanning Electron Microscopy.



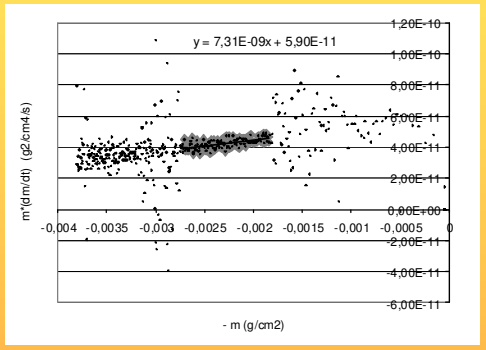


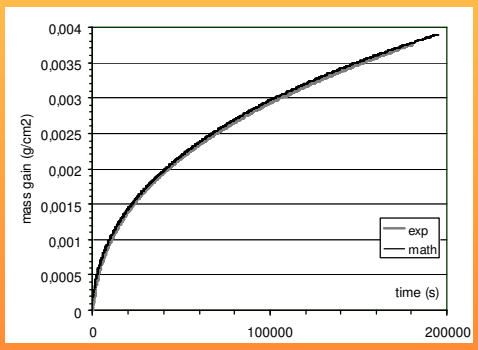
{dm/dt = Kp – Kv . m} - type treatment of mass gain results for Ni30Cr0.4C at 1100°C; validation by comparison between the real curve and the one plotted from the Kp and Kv values

THERMOGRAVIMETRIC AND MICROSCOPY STUDY



The M30Cr0.4C (called M4 with M=Ni, Fe and Co) oxidized alloys





{dm/dt = Kp – Kv . m}-type treatment of mass gain results for Fe30Cr0.4C at 1100°C; validation by comparison between the real curve and the one plotted from the Kp and Kv values

VALUES OF Kp AND Kv DETERMINED FOR ALL ALLOYS AT THE THREE TEMPERATURES

Kp ($x\ 10^{-12}$ $g^2.cm^{-4}.s^{-1}$)	0%C			0.2%C			0.4%C			0.8%C		
	Ni	Fe	Co	Ni	Fe	Co	Ni	Fe	Co	Ni	Fe	Co
1200°C	60	*112*	/[3]	82	*434*[4]	/[3]	70	*433*	/[3]	144	*140*[4]	/[5]
1100°C	22	*53*	24[2]	28	98[1]	/[5]	**18**	**59**	8.5	64	**37**	42[4]
1000°C	2.7	129	1.9[1]	5.7	**19**	1.9[1]	7.1	6.3	**2.7**	*8.7*	**33**	7.1

Kv ($x\ 10^{-10}$ $g.cm^{-2}.s^{-1}$)	0%C			0.2%C			0.4%C			0.8%C		
	Ni	Fe	Co	Ni	Fe	Co	Ni	Fe	Co	Ni	Fe	Co
1200°C	125	*265*	/[3]	143	*160*[4]	/[3]	82	*428*	/[3]	216	*271*[4]	/[5]
1100°C	77	*95*	66[2]	52	204[1]	/[5]	**58**	**73**	10	118	**6.9**	138[4]
1000°C	-2.9	267	8.9[1]	16	**31**	9.0[1]	32	27	***-7.1***	*16*	49	17

Bold characters: excellent fit between the experimental mass gain curve and the mathematical one
Normal characters: good fit between the experimental mass gain curve and the mathematical one
Italic characters: not good fit between the experimental mass gain curve and the mathematical one

1: several serious jumps due to local detachments of the chromia scale
2: catastrophic linear oxidation after about 15 hours
3: catastrophic linear oxidation just after the beginning of the isothermal stage
4: one serious jump due to local detachments of the chromia scale
5: very fast but parabolic oxidation just after the beginning of the isothermal stage

The density of the interdendritic carbides, which are usually considered as special diffusion paths for chromium involved by high temperature oxidation, finally does not clearly influence the oxidation kinetics, neither for nickel alloys which display a good behaviour, nor for the cobalt and iron alloys which are more easily concerned by a rapid oxidation. Nevertheless it was seen that the results of the {dm/dt = Kp – Kv . m}-type analysis sometimes leads to surprising values of the volatilization constant that can perhaps reveal an interesting possible protection against chromia volatilization by the presence of other metallic elements in the external oxides (CoO mixed with Cr_2O_3 or presence of Fe in the M_2O_3 oxide).