CREEP AND CORROSION RESISTANCE OF NI-ALLOYS IN MOLTEN NAF A LIF SALT

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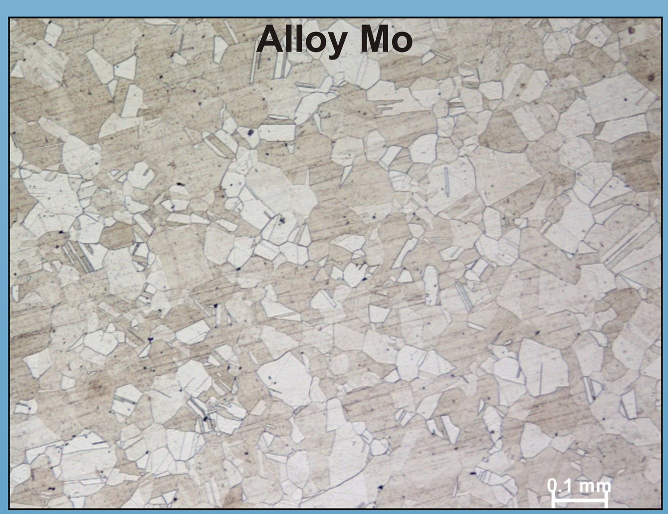
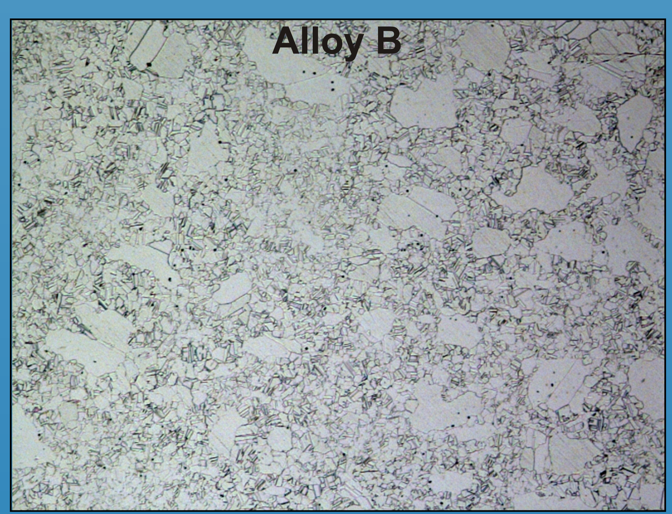
INTRODUCTION

The most promising materials for production of ADDT (Acceleration Driver Transmutation Technology) loop components for spent nuclear fuel transmutation are nickel superalloys. The excellent mechanical properties, creep resistance, corrosion resistance in an environment of fused fluoride salt and resistance against radiation embrittlement are required for these alloys. These alloys have to show good technological properties.

The creep behaviour and high-temperature corrosion in molten fluoride salts of two experimental nickel alloys (MoNiCr type) and a comparative alloy (Hasteloy B type) have been investigated. The creep tests were performed at temperature 700 °C in stress range from 80 to 160 MPa. The corrosion tests have been performed in a protection nitrogen/hydrogen atmosphere at a temperature of 710 °C in environment of molten mixture of NaF and LiF. The corrosion losses have been measured. Surface structure changes were observed using electron microscopy and microanalysis and corrosion mechanisms during tests were specified.

Microstructure



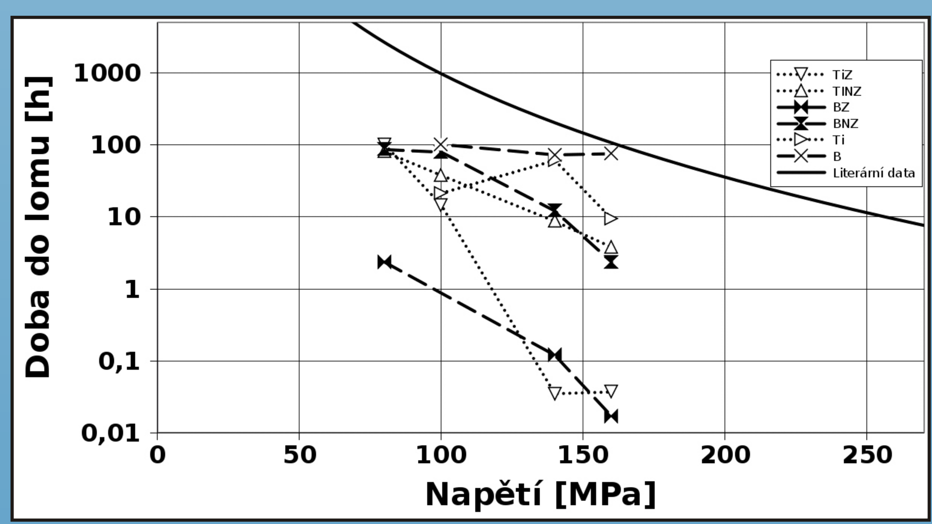


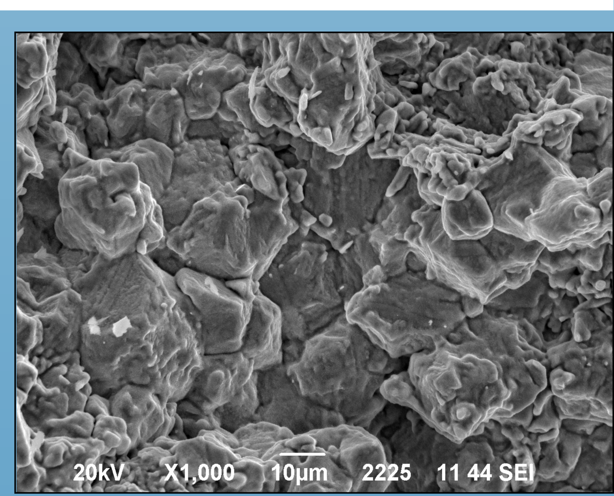
Chemical composition of alloys in %

Melt	Cr	Mo	C	Mn	Fe	Co	Cu	Ti	Ni
Mo	1.05	26.82		1.42	0.55	1.33	0.07		bal
Ti	6.97	14.17	0.02	0.1	2.54	0.11	0.19	2.05	bal
B	6.25	14.44	0.02	0.1				0.1	bal

Results of creep tests

Stress [MPa]	Time to fracture [h]					
	Ti	Ti (Z)	Ti (NZ)	B	B (Z)	B (NZ)
160	9.5	0.037	3.8	75.43	0.017	2.36
140	61	0.035	8.7	72.75	0.120	12.10
100	21.3	14.6	37.8	101.6	Fracture at loading	79.4
80	---	101.6	80.5	---	2.4	86.2

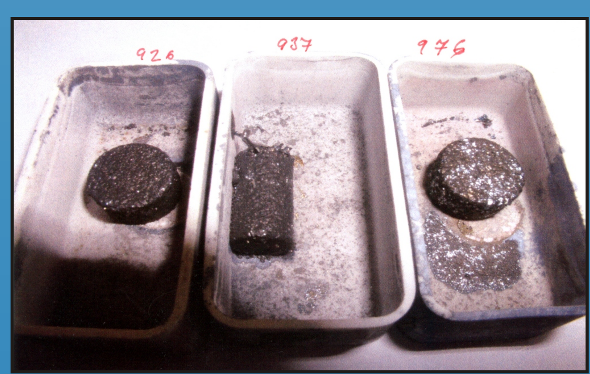




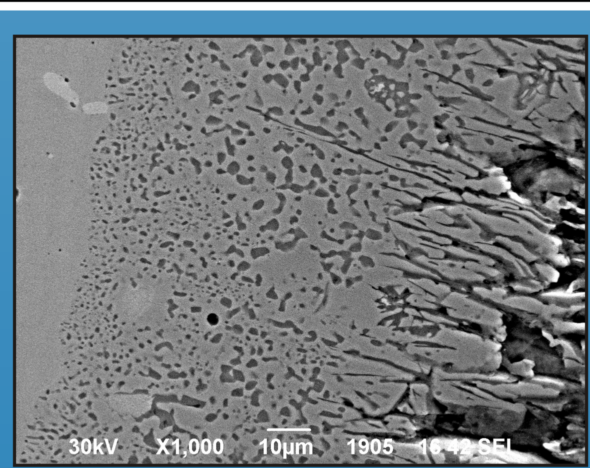
Fracture surface of alloy B

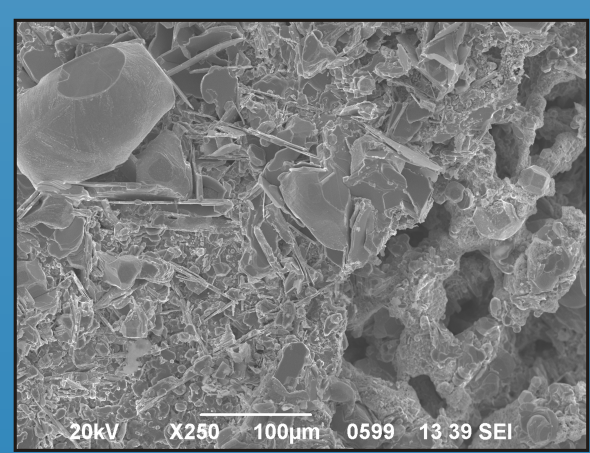
Results of corrosion tests

Melt	State	Corrosio gain for 320 hours	Speed of corrosion in term of growth of oxidation layer [mm/year]	Speed of corrosion in term of growth of thickness loss [mm/year]
HASTELLOY B	Non annealed	63.46	0.21	0.0198
	Annealing 1300°C/10h	56.74	0.19	0.0177
MONICR	Non annealed	87.39	0.30	0.0273
	Annealing 1300°C/10h	80.32	0.28	0.0251



Corrosion tests- general view,





CONCLUSIONS

On the basis of the performed creep tests it can be concluded that the best creep resistance show samples after forging. The other tests are necessary for confirmation of this statement. Creep resistance of alloy B is better then creep resistance of alloy Mo. The results of tests show significant variation.

Failures of creep tests bars occurred by combination of both the integranular and transgranular ductile fracture. The high-temperature oxidation resistance is higher for alloy Hasteloy B in comparison with alloy MoNiCr + Ti.

Corrosion tests performed in environment of molten mixture of NaF and LiF in the protection nitrogen/ 5 % hydrogen atmosphere at a temperature of 710 °C for 320 hours show, that mass gain of alloy Mo are comparable with alloy B. The protective oxidation layer formed on the surfaces of both the alloy. No significant difference between the mass gains was found for forged material and material annealed at 1300 °C.

The corrosion speeds expressed in form of the growth of the oxidation layer in millimetres per year ranged from 0.2 to 0.3 mm/year, which corresponds to loss of wall thickness up to 0.025 mm/year.

Mechanism of formation of the corrosion surface layer is similar for both the alloys. Molybdenum rich particles are formed in the under-surface layer. During the exposure their number and sizes increase. Particles are predominantly of plate-like shape and are oriented perpendicular to the surface. They are surrounded by corrosion channels.

Considering better formability and lower production cost, the MoNiCr alloy is the most promising candidate for application in the ADTT reactors. From the point of view of the nowadays market situation these reactors offer an opportunity to gain an environmental-friend energy and solve a problem of a liquidation of nuclear spent fuel.

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