POLISH ACADEMY OF SCIENCES - COMMITTEE OF MATERIALS SCIENCE
SILESIAN UNIVERSITY OF TECHNOLOGY OF GLIWICE
INSTITUTE OF ENGINEERING MATERIALS AND BIOMATERIALS
ASSOCIATION OF ALUMNI OF SILESIAN UNIVERSITY OF TECHNOLOGY
Conference Proceedings
12th INTERNATIONAL SCIENTIFIC CONFERENCE
ACHIEVEMENTS IN MECHANICAL & MATERIALS ENGINEERING

Corrosion resistance of composite HVOF sprayed coatings with FeAl and NiAl intermetallic phases in aggressive environment

B. Szczucka-Lasota[a], B. Formanek[a], A. Hernas[b], L. Pajak[b]

[a] Silesian University of Technology
Krasińskiego 8, 40-019 Katowice, Poland

[b] University of Silesia
Bankowa 12, 40-007 Katowice, Poland

The results of high temperature corrosion of coatings with FeAl and NiAl intermetallic matrix in sulfur and chlorine contaminated air at 1273 K are presented. The macrostructure of sample surface after the test corrosion is shown. Kinetics test was carried out by periodic oxidation method. The weight increase of growing scale after established time was determinated. The corrosion process of studied composite coatings obeys parabolic rate law. The morphology and chemical composition of the corrosion products on the surface of coatings were determinated by scanning microscopy observation. The surface scale formed on coatings with FeAl and NiAl intermetallic matrix was homogenous and whiskers of oxides were not observed. The phase composition of corrosion products are also presented. All investigations on corrosion resistance confirm good properties of composite coatings with intermetallic phases to application for elements working at high temperature and corrosion environments.

1. INTRODUCTION

The structural materials based on intermetallics from Fe-Al system are developed for application in processing industry and power generation systems. The perspective materials exhibit excellent resistance to corrosion in single and multi-oxidant environments at elevated temperature. The good corrosion resistance of these intermetallics are determinated through the formation of slow-growing, adherent alumina scales [1-4]. In the present paper the results of high temperature corrosion of coatings with FeAl and NiAl intermetallic matrix in aggressive environments with oxygen/sulfur and chlorine mixed gas at 1273 K are presented.

2. MATERIALS AND EXPERIMENTAL PROCEDURE

The base materials are composite powders of matrix with FeAl and NiAl intermetallic phases obtained by SHS method [5-6]. The composite materials were thermally sprayed on

K10 steel by HVOF method in Jet Cote II system. The structure of base materials and X-ray diffraction pattern are presented in figure 1. The materials for research are thermally sprayed fine-dispersive composite coatings. The phase compositions of composite coatings are: FeAl-Fe_xAl_y and NiAl -Al_2O_3.

One part of the thermally sprayed coatings were sealed by the inorganic phosphate seal [7-8].

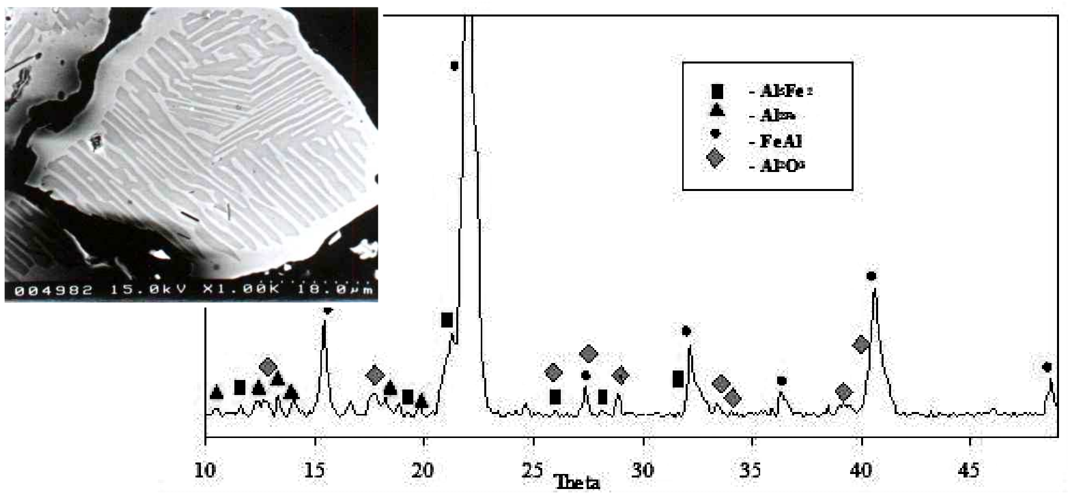


Fig. 1. Ligh microscopy image and X-ray diffraction pattern of FeAl-Fe_xAl_y composite coatings.

Kinetics tests of the mass change of the coatings are carried out by periodic oxidation method. The procedure of corrosion resistance test at 923K obeys tree stages: heating to 923K ; annealing at this temperature during 24, 48, 72…500 hours and cooling to the room temperature. Thought the quartz heating tube with samples flow the aggressive gas: **N_2 + 9% O_2 + 0,2% HCl +0,08% SO_2** The scheme of installation to research the gaseous corrosion is shown in figure 2. The weight of growing scale after 24, 48, 72…500 hours was determined. The surface of coating after corrosion test was observed by light microscopy (Richert 2). The morphology and chemical composition of the corrosion products after the test was determinated by Hitachi S-4200 scanning microscopy with voyager system (an analysis system of the characteristic X-radiation of elements by Noran system). The phase composition of corrosion products was conducted by an X-ray diffraction method using a Philips diffractometer with a graphite monochromator of diffracted beam; CuK_a radiation was applied.

3. RESULTS AND DISCUSSION

The macrostructure of the coatings after the corrosion process is shown in figure 3. The structure have not any cracking and changes of colors. The curves of mass change as a function of the heating time are shown in figure 3. The morphology of the corrosion products on the intermetallic coatings after 48 and 500 hours corrosion test are presented in figures 4 and 5. The chemical composition of the coatings determinated by EDS technique are presented in figure 6. The surface scale formed on FeAl and NiAl intermetallic matrix coatings was homogenous and whiskers of oxides are not observed. The morphology and the chemical compositions of the samples with phosphate-seal confirm high corrosion resistance of this materials. The phase composition of the corrosion products after the test corrosion is shown in table 1.

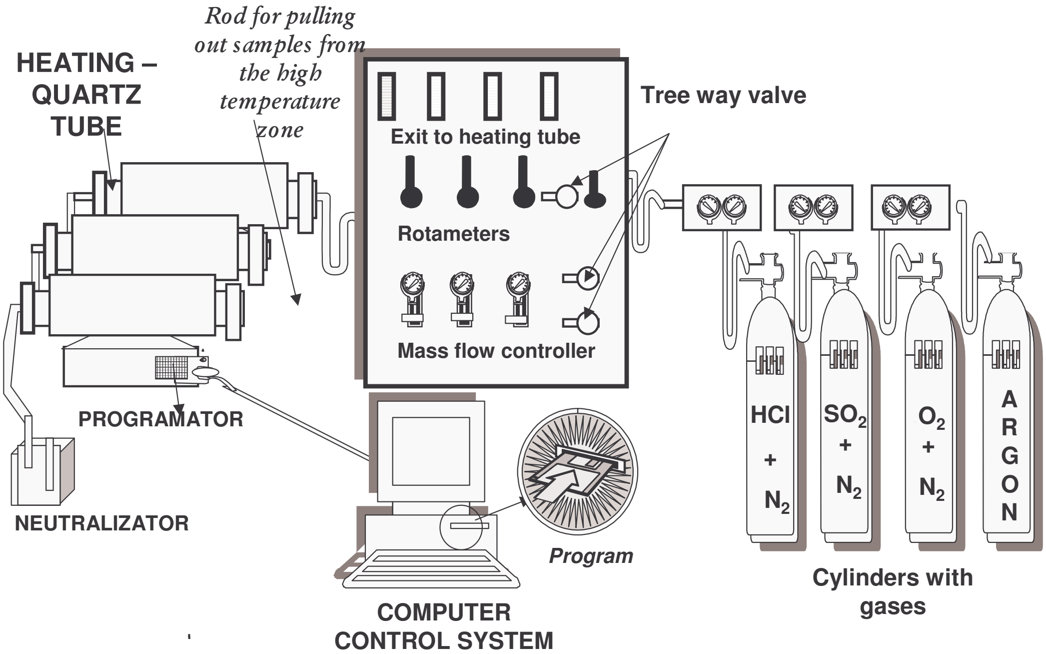
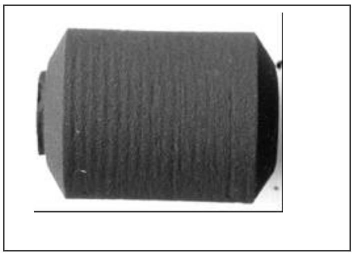
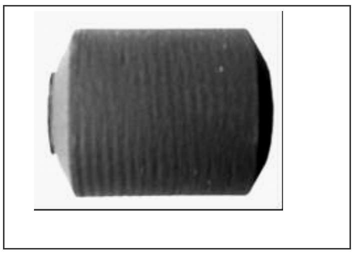


Fig. 2. The scheme of installation to research the gaseous corrosion.



a) 48 hours



b) 500 hours test

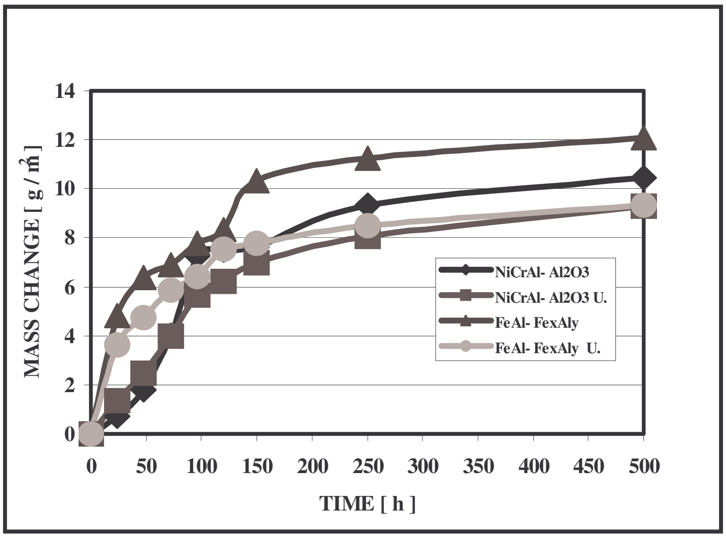
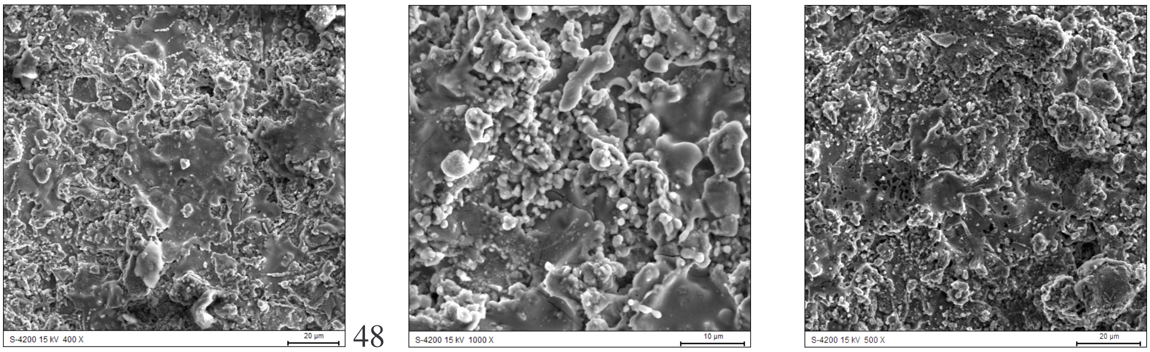
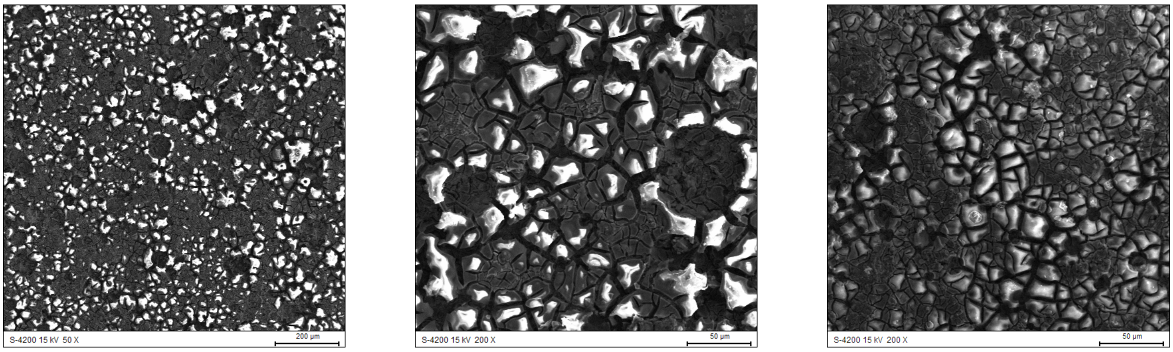


Fig. 3. The images of surface of HVOF sprayed coatings after the corrosion test a) 48 h; b) 500 h and the curves of mass change as a function of the heating time.



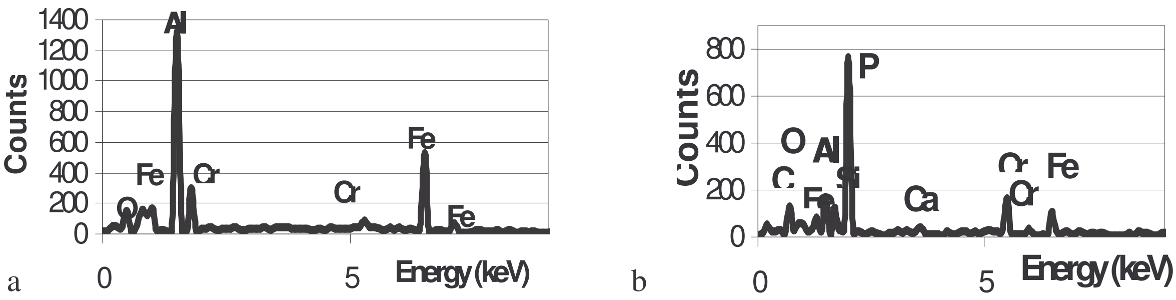
48 hours corrosion test 48 hours corrosion test 500 hours corrosion test

Fig. 4. The morphology of corrosion products on FeAl-Fe_xAl_y coatings.



48 hours corrosion test 48 hours corrosion test 500 hours corrosion test

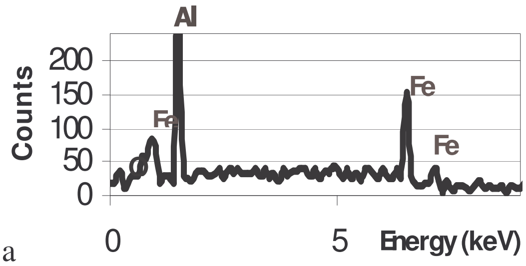
Fig.5. The morphology of FeAl-Fe_xAl_y coatings with the inorganic seal.



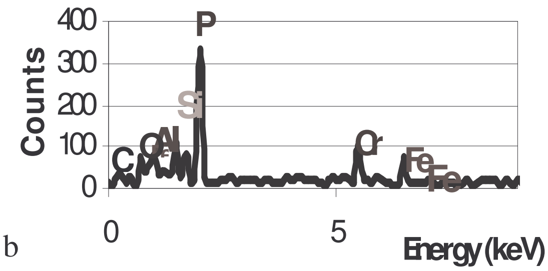
Elements	Atom%	Weight %
O	10.96	4.75
Al	42.65	31.19
Si	7.91	6.02
Cr	2.14	3.01
Fe	36.35	55.03

Elements	Atom%	Weight %
O	38.10	20.33
Al.	5.68	5.12
Si	2.82	2.64
P	30.84	31.86
Ca	0.86	1.14
Cr	11.75	20.37
Fe	9.95	18.53

Fig. 6. The chemical composition of corrosion products after 48 hour test on: a) FeAl-Fe_xAl_y coating b) FeAl-Fe_xAl_y coating with seal



a



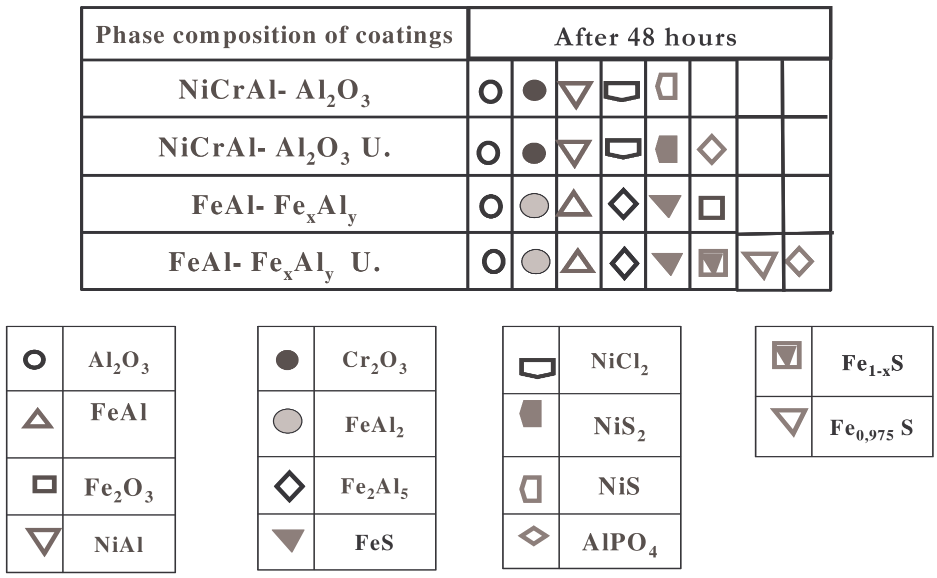
b

Elements	Atom%	Weight %
O	0.00	0.00
Al	53.09	35.35
Fe	46.91	64.65

Elements	Atom%	Weight %
O	35.19	19.22
Al	7.97	7.34
P	24.53	25.94
Cr	9,08	16,12
Fe	11,42	21,78
Si	1.95	1.87
Na	9,86	7.73

Fig. 6. The chemical composition of corrosion products after 500 hour test on: a) FeAl-Fe_xAl_y coating b) FeAl-Fe_xAl_y coating with seal

Table 1. The phase composition of the corrosion products on the composite coatings after 48 hours test



4. CONCLUSION

The composite HVOF sprayed coatings with FeAl and NiAl intermetalic phases reveal the high corrosion resistance in the test conditions of aggressive gaseous atmosphere N_2 + 9% O_2 + 0,2% HCl +0,08% SO_2. Sealing process of coating surfaces increased the corrosion resistance of coatings. The coatings are preferred to application as protection of the water-walls and of boiler tubes for combustion the waste. The composite coatings are the perspective materials in applying at elevated temperature in multi-oxidant and reduction environments.

This work is financially supported by State Committee for Scientific Research (grant PBZ/KBN 041/T08/2001 and grant PBU/KBN 041/T08/2002)

REFERENCES

1. K. Yamada, Y. Tomono, J. Morimoto, Y.Sasaki, A. Ohmori, Vacuum 65 (2002) pp. 533-540.
2. K. Natesan, Materials Science and Engineering A258 (1998) pp.126-134
3. P. F. Tortorelli, K. Natesan, Materials Science and Engineering A258 (1998) pp.115-125.
4. I. Kim, W. D. Cho, Materials Science and Engineering A264 (1999) pp. 269-278
5. B. Formanek, B. Szczucka-Lasota, A. Letsko, Achievement in Mechanical and Materials Engineering, ed. L. A. Dobrzanski, (2002) pp. 187-190.
6. B. Formanek, K. Szymanski, B. Szczucka-Lasota, B. Bierska, Inżynieria Materiałowa v. 6,137 (2003) pp. 617-620
7. Sealing Technology v. 2, 8 (2002) pp. 10.
8. M. Vippola, J.Vuorinen, P. Vuoristo, T. Legisto, T. Mantyla, J.F. Ener.Ceram.Soc. v22, 12 (2002) pp. 1937-1946.