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Oxidation of thermally sprayed coatings with FeAl intermetallic matrix

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The results of high temperature oxidation of FeAl-Fe_xAl_Y coating with and without seal at 1223 K is presented. Kinetics test was carried out by periodic oxidation method. The oxidation process of studied composite coatings obeys parabolic rate law. The structure of composite coatings after oxidation test was determinated by light microscopy observation. The morphology and chemical composition of the corrosion products on the surface of coatings are presented. The morphology of surface scale formed on FeAl-Fe_xAl_y coating with and without seal is different. The coating with inorganic seal it was homogenous and whiskers of oxides were not observed. The phase composition of corrosion products are presented. All investigations on oxidation resistance confirm good properties of composite FeAl-Fe_xAl_y coatings to application for elements working at elevated temperature.

1. INTRODUCTION

The composite coating with FeAl intermetallic phase is of great interest at high temperature applications. First of all this material has excellent oxidation resistance. The good properties of intermetallics based on the high aluminum activity are determinated through the formation of slow-growing, adherent alumina scales [1-3].

In this article the results of high temperature oxidation at 1223 K of composite coatings with FeAl intermetallic matrix and sealed by the inorganic phosphate seal are presented. In the present study it is shown, that the sealing process of coating surfaces increases the corrosion resistance of HVOF sprayed intermetallic coatings.

2. MATERIALS AND EXPERIMENTAL PROCEDURE

The materials for research are composite coatings thermally sprayed on K10 steel by HVOF method in Jet Kote II system. The phase composition of these coatings is FeAl-Fe_xAl_y. One part of the fine-dispersive coatings was sealed by the inorganic phosphate seal. The microstructure of base materials is presented in figure 1.

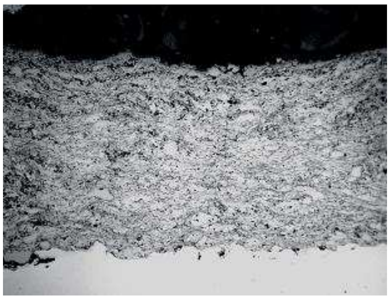
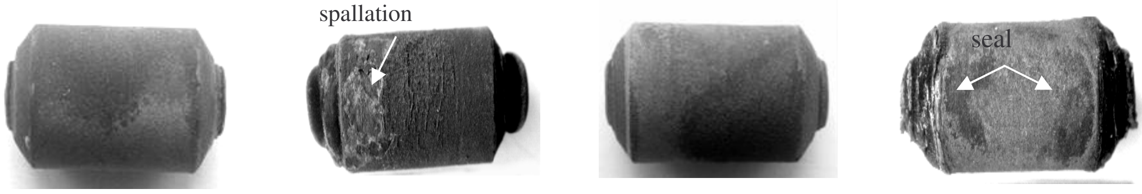


Fig. 1. Light microscopy image of FeAl-Fe_xAl_y composite coating

Kinetics tests of the mass change of the coatings are carried out by periodic oxidation method in Carbolite furnace. The procedure of oxidation resistance test at 1223 K obeys tree stages: heating to 1223 K ; annealing at this temperature during 24, 48, 72…500 hours and cooling to the room temperature. 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 (analysis system of the characteristic X-radiation of elements by Noran system). The phase composition of corrosion products was performed by an X-ray diffraction method. The diffraction pattern were collected using X-Pert Philips diffractometer equipped with graphite monochromator on diffracted beam and with the following slits (in the sequence from Cu tube to counter): Soller (2^o), divergence (1/2°), antiscatter (1/2°), Soller (2^o) and receiving (0.15 mm).

3. RESULTS AND DISCUSSION

The images of surface of HVOF sprayed coatings after the 48 and 500 hours oxidation test are shown in figure 2. The color of FeAl-Fe_xAl_Y coating surface without seal changes and slight spallation appears. The structure of composite coatings after 48 hours oxidation test with adherent alumina scales is shown in figure 3. The curves of mass change as a function of the heating time are shown in figure 4. The mass change of the all studied composite coatings was comparable and the oxidation process of these materials obeys parabolic rate law. The morphology of the corrosion products on the intermetallic coatings after 48 and 500 hours corrosion test are presented in figures 5 and 6. The surface scale formed on coatings without seal was not homogenous and whiskers of oxides were observed. The chemical compositions of the coatings determinated by EDS technique are presented in the tables in figures 5 and 6. 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 oxidation test is shown in figure 7.



a) 48 h b) 500 h c) 48 h d) 500 h

Fig. 2. The images of surfaces of HVOF sprayed coatings a-b) without seal and c-d) with seal

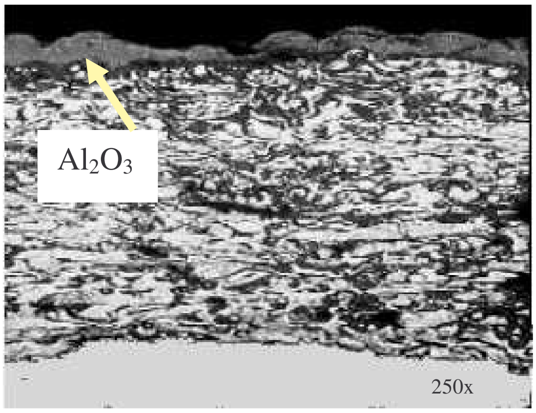


Fig. 3. The structure of FeAl–Fe_XAl_Y coating after 500 hours oxidation test

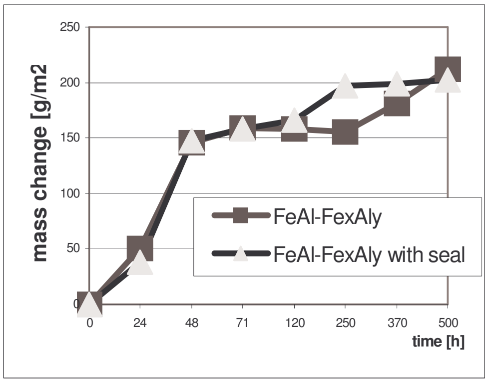
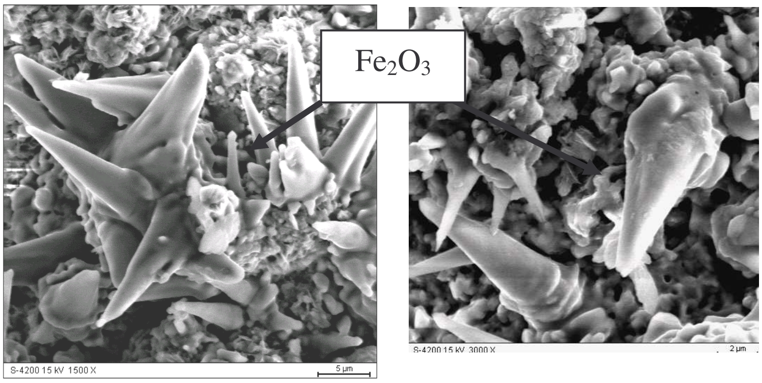
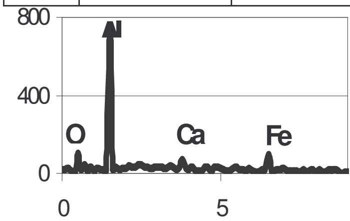


Fig. 4. The curves of mass change as a function of the heating time



	at.%	wt. %.
O	38.77	23.25
Al	45.43	45.94
Ca	3.43	5.15
Fe	12.37	25.66



Whiskers structure

Fig. 5. The morphology and chemical composition of the corrosion products on the surface of the FeAl- Fe_xAl_y coating

	at.%	wt.%
O	19.92	7.22
Al	10.42	96.37
P	1.84	1.29
Ca	1.71	1.55
Mn	3.29	4.64
Fe	62.82	78.92

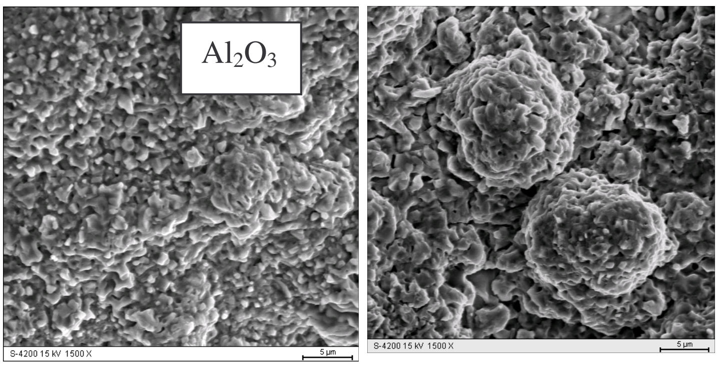


Fig. 6. The chemical composition and morphology of the corrosion products on the surface of the FeAl- Fe_xAl_y coating with seal.

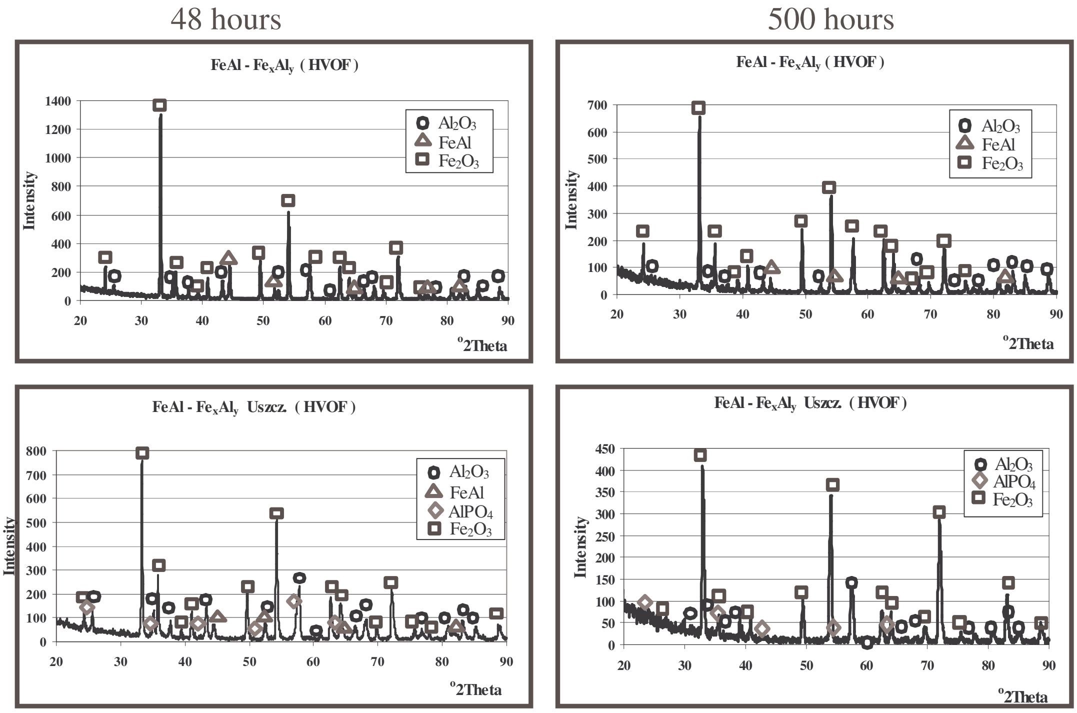


Fig. 7. The phase composition of the corrosion products on the composite coatings after 48 hours oxidation test

4. CONCLUSIONS

The good oxidation resistance of FeAl-Fe_xAl_y coatings is the result of the growth on the surface of the stable α-Al_2O_3 scale. The sealing process of coating surfaces increases the oxidation resistance of studied coatings in the test conditions at 1223 K. The coatings are preferred to application as protection of the water-walls and tubes in boilers for combustion the hard cool.

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