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Composite carbide powders and HVOF sprayed coatings with a plastic matrix

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ABSTRACT

Purpose: The paper presents the characterization of powders containing hard phases of chromium and titanium carbides in a plastic matrix, intended for thermal spraying of coatings. The synthesized powder composites containing chromium carbides, produced in high-temperature activated syntheses has been presented.
Design/methodology/approach: Commercial materials, such as NiCr- Cr_xC_y, are fabricated by means of technologies applied in powder metallurgy. The influence has been determined of the chemical composition and size analysis of original blends and synthesis processes on the products obtained. The powders NiCr-Cr_3C_2 –TiC and FeCr- Cr_3C_2-TiC are manufactured by self-activated high temperature synthesis. The synthesized powders were thermally sprayed by supersonic method in HVOF - Jet Kote II system. The structure and phase composition of the powders and coatings were determined by: scanning microscopy, X-ray phase analysis, energy dispersive X-ray analysis (EDX) and X-ray diffraction analysis.
Findings: The structure and application of HVOF sprayed coatings containing chromium and titanium carbides has been presented.
Practical implications: The HVOF thermally sprayed coatings are characterized high erosion- corrosion resistance of wear at elevated temperature.
Originality/value: The paper presents the characterization of new type of NiCr-Cr_3C_2 –TiC and FeCr- Cr_3C_2-TiC powders.
Keywords: Powder metallurgy; Composite powders; Coatings

1. Introduction

Composite powder containing chromium and tungsten or titanium carbides belong to tree group of materials recommended for the production of thermally sprayed coatings of high resistance to wear and corrosion. Powder of NiCr(80/20)/Cr_3C_2 type find application in plasma and HVOF sprayed coatings [1-5]. The are resistance to abrasion, erosion wear and high temperature corrosion.

Powders with some chemical composition manufacturing by different techniques, namely: blended, sintered, and crushed and more complicated procedure. The high energy ball milling is an effective process for the synthesis of nanostructure powders. [6-8]

The complex technology of powder materials and coating product ion for scientific application are presented due to commercial reasons.

The anticipated improvement of functionally properties of coatings can be obtained by modification of the chemical and phase composition of powders. [1-9]

2. Objective and scope of the study

The main objective of the research was to determine and verify the material and technological conception of the production of composite powders containing hard phases of chromium carbides with a metallic matrix, as well as the selection and verification of the powders' synthesis parameters and the determination of the structure and phase composition of the powders synthesized. It was assumed that NiCr–Cr_xC_y powders will be manufactured in combined processes of mechanical alloying and high-temperature synthesis. Cr_3C_2 –TiC composite powders in NiCr and FeCr matrices were produced in an activated high-temperature synthesis. Another objective of the research was to develop a new technological procedure for the production of powders which would use the exothermic element of the synthesis of carbide phases in a plastic matrix of NiCr or FeCr alloys. The scope of the study included:

- the development of a technological conception of powders production in combined processes of mechanical alloying and high-temperature synthesis,
- the development of a technological procedure of the production of powders containing carbide phases in an activated high-temperature synthesis,
- the preparation of original mixtures for the syntheses, of a desirable chemical composition and granulation,
- the selection of the right parameters for mechanical stirring, homogenization and powders' size reduction,
- the selection of parameters for the high-temperature synthesis of powder mixtures,
- the synthesis of the composite powders,
- the determination of the morphology, phase composition and basic physicochemical properties of powders obtained in the syntheses.
- the determination of technological parameter for obtaining thermally sprayed coatings.
- the determination of the structure and phase composition of coatings

3. Materials and research methodology

For the composite powders' synthesis, commercially available powders of chromium, titanium, hard carbon black, and chemical process activators were used. The original powders' granulation was selected depending on the technological variant of manufacturing the products. In the mixtures, Fe30Cr and Ni20Cr powders were also applied as a plastic matrix. Flow diagram of powders production is presented in the fig. 1.

For the determination of powders' structure and phase composition, light and scanning microscopy methods as well as a microanalysis and X-ray analysis were used.

The morphology of original powders and the chemical composition of the synthesized composite powders were determined using a scanning electron microscope, Hitachi S-4200, equipped with a characteristic X-radiation Noran detector and a Voyager computer system.

Metallographic specimens were observed on a CARL ZEISS light microscope with a digital image recording. system.

Examination of the powder phase composition was conducted on JEOL's JDX-7S diffractometer with a vertical focusing system. The source of radiation was a lamp with a copper anode; graphite beam monochromatization was applied. Phase identification was performed with the aid of a computer programme PCSIWIN which uses the database in the form of records of the JCPDS-International Centre for Diffraction Data 2000.

Selected powders were supersonic sprayed in the Jet Kote II system, with applying the predetermined technological process parameters.

The coatings produced by thermal spraying were examined by research methods applied for powders' investigations.

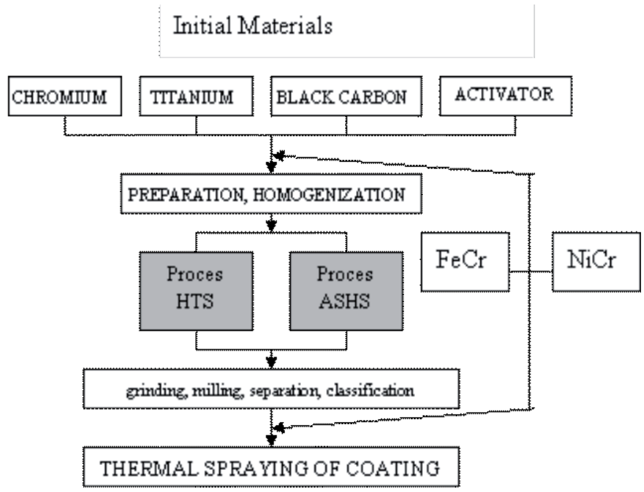

Fig. 1. Flow diagram of powders production

4. Research results

The morphology of powders produced in synthesis processes is presented in Fig. 2.

Powders can be obtained of a predefined dispersion structure and a defined phase composition by selecting the powders' granulation, the parameters of the mechanical homogenization process and the conditions for a high-temperature synthesis. A supposition can be made that application of mills of higher energy than that of the applied rotary-vibration mill for powders' mixture homogenization will allow the obtaining of powders with a higher fraction volume, of up to 56 µm.

Investigation results of the phase composition synthesized powders are presented in fig. 3 and 4.

The coating produced are characterized by low porosity and dispersive structure of carbide phases in NiCr and FeCr matrix. Investigation results of chemical composition of HVOF thermally sprayed coatings are presented in fig.5, 6, 7, and table 1, 2 (atom %).

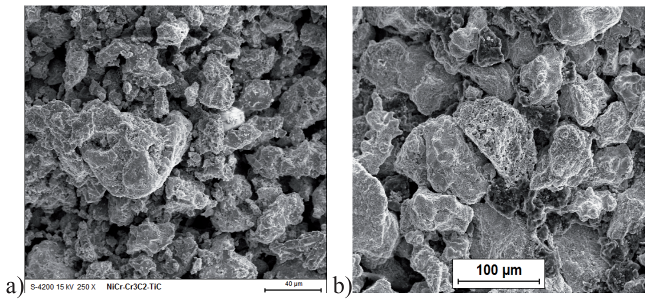

Fig. 2. Morphology of powders: a) NiCr-Cr_3C_2-TiC, b) FeCr-Cr_3C_2-TiC

The coating produced are characterized by low porosity and dispersive structure of carbide phases in NiCr and FeCr matrix. The result of the investigations carried out was the selection of technological parameters for the production of composite powders containing chromium carbides or their mixture with titanium carbide.

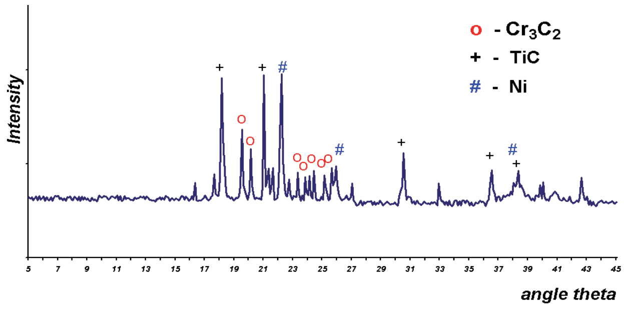

Fig. 3. X-ray diffraction pattern of NiCr-Cr_3C_2-TiC powders

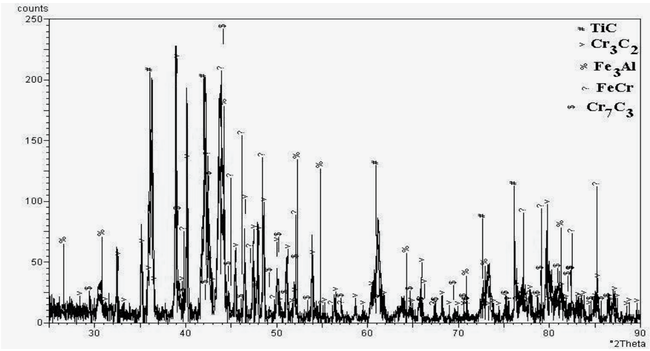

Fig. 4. X-ray diffraction pattern of FeCr-Cr_3C_2-TiC powders

The application of the right method of composite powders' synthesis activation enables the obtaining of powders of a predefined phase composition. The characteristic morphology of powders of irregular shapes, obtained in a high-temperature synthesis, is not beneficial for the processes of thermal spraying of coatings.

A correction of the parameters of the process in which the powders are obtained, or their superficial modification, should ensure the obtaining of higher quality powders.

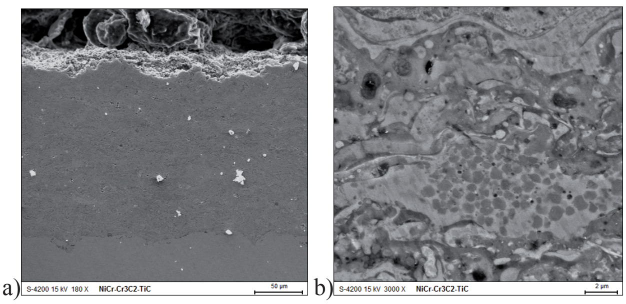

Fig 5. Microstructure of NiCr-Cr_3C_2-TiC HVOF sprayed coating (SEM).

Table 1.
Chemical compositions of NiCr-Cr_3C_2- TiC coatings (fig 5),

NiCr-Cr_3C_2-TiC	Mo-K	Ti-K	Cr-K	Fe-K	Ni-K
Average a)	3,20	35,59	42,90	1,46	16,85
Point b	7,5	47,79	12,01	-	32,63

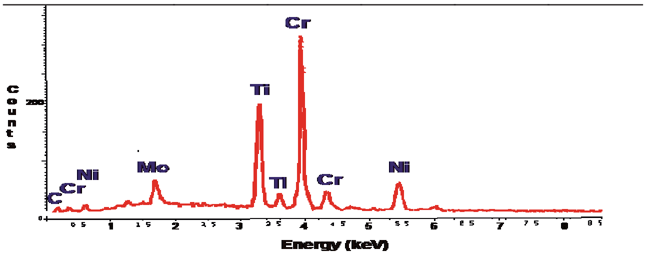

Fig. 6. EDX of NiCr-Cr_3C_2-TiC HVOF sprayed coating (fig. 5)

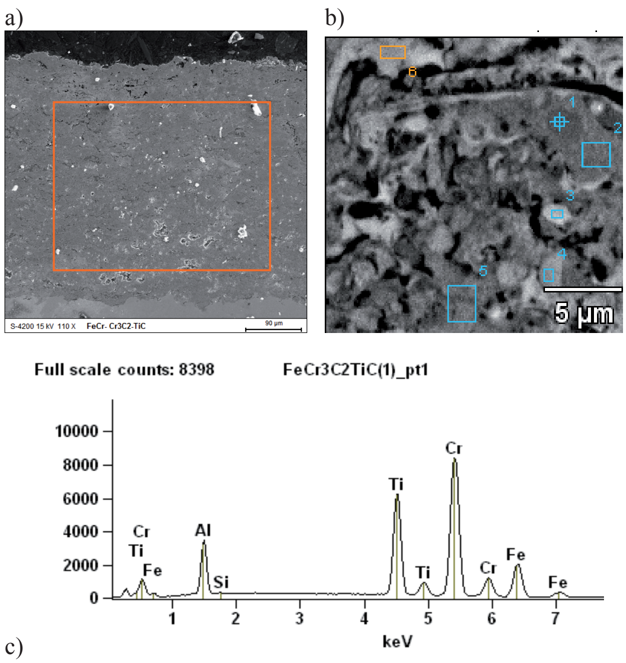

Fig. 7. Microstructure (SEM) and EDX analysis of FeCr-Cr_3C_2-TiC coating with measurement areas

Table 2.
Chemical compositions of FeCr-Cr_3C_2- TiC coatings (Atom %)

FeCr- Cr_3C_2- TiC	Al-K	Si -K	Ti -K	Cr-K	Fe -K
Average	22.75	0.45	22.60	40.94	13.27
Point 1	9.4	0.3	62.2	18.9	9.0
Point 2	23.8	0.7	40.0	15.2	20.1
Point 3	5.3	0.2	14.1	75.1	5.12
Point 4	3.6	0.2	6.85	82.1	7.11
Point 5	10.3	0.7	21.1	55.6	12.1
Point 6	5.2	0.2	5.4	82.8	6.10

4. Conclusions

The assumed technological conception, according to which the process of composite powders production from a mechanically homogenized mixture of starting components should be a high-temperature synthesis with classification, is a simple and economically efficient method.

The presented process of NiCr and FeCr - based chromium carbide powders production constitutes an alternative for the production of commercial powders used for thermal spraying of coatings by supersonic (HVOF) or plasma methods. The multiphase's structure of thermally sprayed NiCr- Cr_3C_2-TiC and FeCr-Cr_3C_2-TiC coatings is characterized by dispersion carbide phases in an alloy matrix.

The HVOF thermally sprayed coatings are characterized high erosion- corrosion resistance of wear at elevated temperature. [10-12]

The application example of the HVOF spraying technology of coatings containing carbides and characterized by high resistance erosion - corrosion wear are presented in fig. 8.

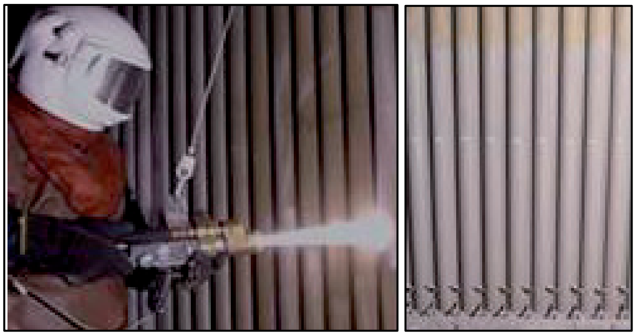

Fig. 8. Example of HVOF sprayed protection coatings for water wall in FCB boiler

Composite coatings are recommended for operation under complex wear conditions at elevated temperatures. The assumed material-technological conception of coating production for composite powders with chromium and titanium carbides has been confirm by the obtained results.

The results presented are part of the research conducted under Project no. 4 T08C 008 25 "Composite materials and coatings thermally sprayed with HVOF and HVAF supersonic methods, of high resistance to corrosion and erosive wear" sponsored by the Ministry of Science and Information Technology.

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