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CHARACTERIZATION OF METAL POWDER NiCrAlY COATING APPLIED BY HVOF PROCEDURE

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ABSTRACT
In conducted research was made a characterisation of metal powder NiCrAlY, before and after applying on the base material. Coating was carried out by using HVOF Diamond Jet procedure, which uses the kinetic energy of the metal particles produced by an explosion of combustible gases. Characterisation was based on chemical analysis of metal powder particles, their size and structural composition, and testing the composition and structure of the applied coating on stainless austenitic steel with intermetallic strengthening UNS S66 286 (alloy A286). We used the classical testing methods of composition of metal powder and coating and optical and scanning electron microscopy in determining the phase composition. In addition to determining the phase composition of applied metal coating, was used and x-ray structure analysis.
Keywords: metal powder, metal coating, superalloy, the microstructure

1 INTRODUCTION
NiCrAlY metal powder is used for applying metal coating using HVOF procedure (High velosity oxsyfuel), on the high-quality stainless and heat resistance steels and superalloys based on nickel and iron. It is also used as a metal surface when applying a coating of ceramics. Applied coatings, increase the heat resistance of alloys, which can improve other exploitation properties that are important for the operation at high temperatures. The main application of these materials is in air and missile technology, and recently in other industries too, particularly in the auto industry. For efficient operation of applied coating, it is important to select appropriate technological application process and choose a coating which, combined with the basic material can achieve the best properties in specific exploitation conditions. Studies have been conducted to reconstruct mechanisms that take place in the applied coating during deposition, and exploitation. Knowing the characteristics of the metal powder is of great importance, because manufacturers usually provide instructions for use only with a catalog values of certain parameters that are not sufficient to fully perceive the function of the applied metal powder in interaction with basic alloy. In the literature generally these data are not available, because each procedure of applying coating has its own peculiarities in the process.

2. METAL COATING AT HVOF DIAMOND JET PROCEDURE

Metal coatings which are formed by applying a metal powder NiCrAlY by HVOF Diamond Jet procedure on the material surface, are dense nonporous high strength and toughness. Properties of coating characteristics are influenced by deposited layers and their phase composition, proportion and distribution of oxides, content of pores and undissolved particles, cohesive strength and adhesion. The properties of the coating are determined by the parameters of macro, micro and submicro structure. The main structural elements of the coating are different from the base metal alloy, so at the selection of metal powder we have to take account of the structure of the applied coatings to be more close to its configuration structure [1].

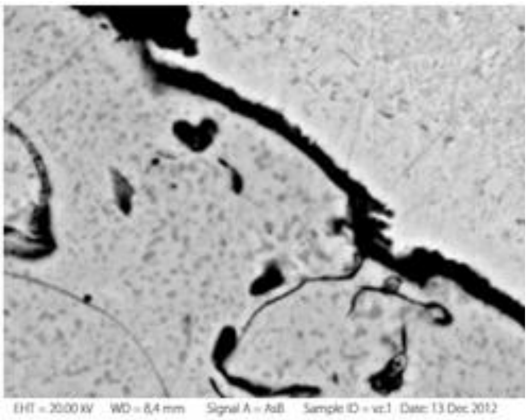


Figure 1. material A286 and intermediate boundaries within the coating.

In the metal coating, near the boundaries of the coating-base material, are present intermediate boundaries and boundaries between applied powder particles themselves (Figure 1).

Forming of different boundaries is a consequence of particle collisions with the inactive (passive) surface of the base material and the interactions between metal powder particles themselves. The boundary of the coating-base material represents only a mechanical mixture without noticeable process of diffusion and dissolution, which indicates that Diamond Jet procedure is a process of mechanical activation.

3. METAL POWDER NiCrAlY

3.1. Testing of metal powder NiCrAlY Sulzer Metco 4516

Characterization of metal powder NiCrAlY Sulzer Metco 4516 was done on the basis of the chemical composition, microstructure of the particles, their size and morphology [2,3]. The shape and dimensions of the particles are determined by the optical microscope (OM), and phase composition by Scanning Electron Microscope (SEM), using a linear, mapping and quantitative EDS analysis.

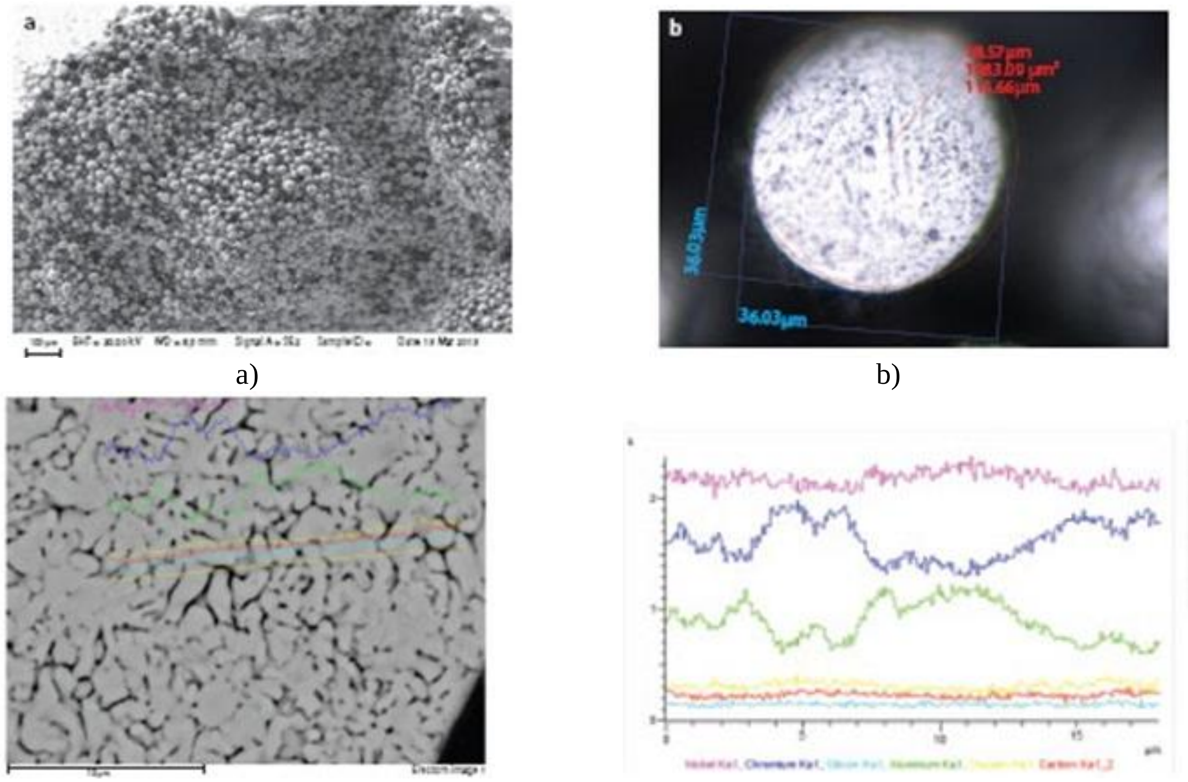
In Table 1 are given in parallel, the chemical composition of metal powder NiCrAlY Sulzer Metco 4516 by catalog, and the coating composition after applying to the alloy A286 in unannealed condition. The table also lists the values of hardness and particle size according to the catalog and after measurements.

Table 1: Chemical composition, hardness and particle size of the metal powder NiCrAlY Sulzer Metco 4516

Sample	Content of elements,%				Hardness, HV	Particles size, µm
	Cr	Al	Y	Ni		
Prescribed values	22,0-24,0	8,0-10,0	0,1-0,3	Rest	346-357 $HV_{0,3}$	20-40
Metal powders, NiCrAlY	24,6	10,5	0,20	64,5	-	36,3
Metal coating, NiCrAlY *	23,8	9,5	0,12	62,8	363-385 $HV_{0,1}$	-

*Thermaly untreated condition

Based on the results of chemical analysis, it is observed that during the process of depositing of metal powder on alloy A286 came to some oxidation loss of elements, which is of importance for the formation of the microstructure of the coating and further evaluation of phase transition [1,2]. On 2a is given the appearance of metal powder NiCrAlY and Figures 2b and c, show the microstructure of particles under different magnification. It is noted that the metal particle has a cast dendritic structure, consisting of two microstructural phases. By line, mapping and quantitative EDS microanalysis, it was found that that in the dark areas were formed intermetallic phase beta-NiAl (rich with alminium and poor with chrome), while in the bright fields existed mixed solid solution of chromium and nickel (Figure 2d).



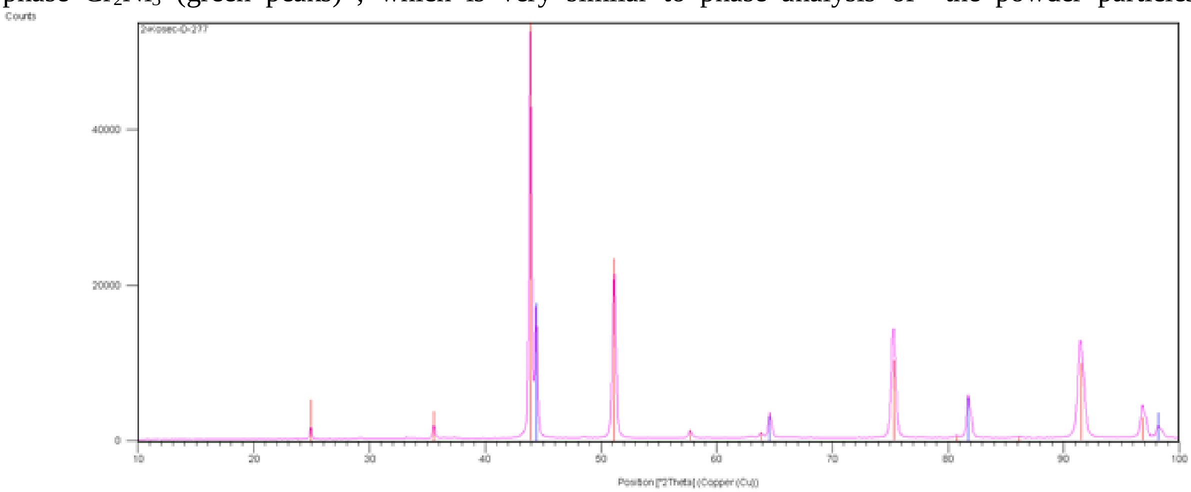
a) b)

c) d)

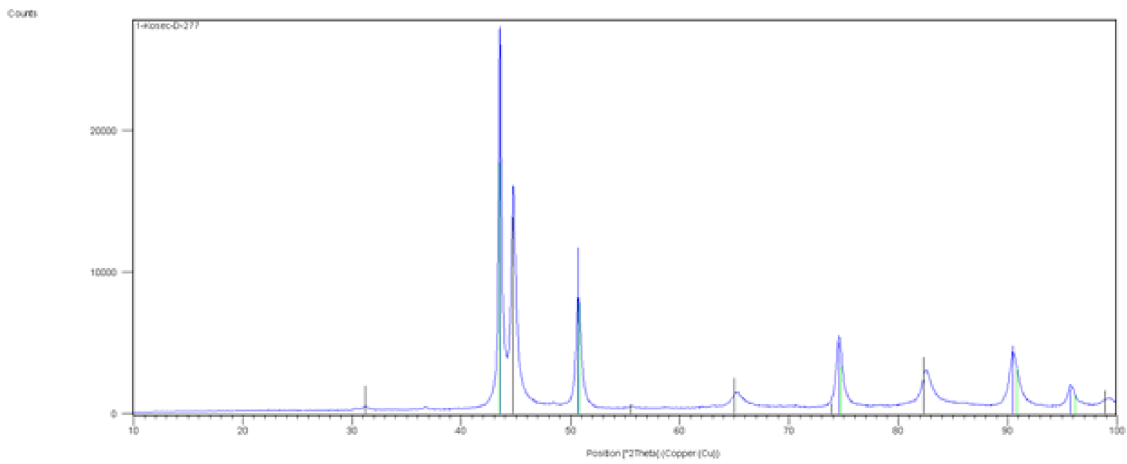
Figure 2. NiCrAlY metal powder (a), the dimensions of the powder particles (b), SEM microstructure (c) linear and EDS analysis (d)

3.2. X-ray examination of NiCrAlY coating

The structural composition of metal coating NiCrAlY was determined by X-ray structure analysis on X-ray diffractometer. Sample preparation was performed by applying a NiCrAlY coating thickness of 200 mm at the plate dimensions ≠ 5X15X40 mm of alloy A286 by Diamond Jet procedure. Applied coatings were tested with two samples, one in the thermally untreated condition and the other in precipitación strengthened condition, after annealing at 720° C for 12 hours. Test results are presented in the radiograph image 3.a and b, wherein it was found that the metal coating NiCrAlY in thermally untreated condition, was consisted of a beta-phase intermetallic $Ni_{1.1}$ $Al_{0.9}$ (black peaks), and the cubic phase Cr_2Ni_3 (green peaks) , which is very similar to phase analysis of the powder particles.



a)



b)

Figure 3. X-ray of metal coating NiCrAlY in thermally untreated condition(a) and in the heat treated condition (b)

Test results of NiCrAlY coating after heat treatment, were presented at the radiograph in Figure 3b The microstructure consists of intermetallic ϒ 'phase (Ni_3Al), (red peaks), and a solid solution of chromium (blue peaks). NiCrAlY coating composition, which has a high content of nickel and aluminium, results in the formation of intermetallic phase ß- $Ni_{1.1}$ $Al_{0.9}$ and after heat treatment comes to the formation of more suitable intermetallic phase ϒ '- Ni_3Al. It is associated with an increased diffusion of aluminium at high temperatures, which causes changes in stoichiometric amounts in these intermetallic phases [4,5].

4. CONCLUSION

The test results provide useful information about the genesis of the development of metal coating and its characteristics at high temperatures. It was found that the morphology and configuration of metal powder have the greatest influence on the properties of applied coating. Tests determined the chemical composition of metal powder NiCrAlY and metal coating applied to alloy A286, after application and subsequent thermal treatment. The analysis of the SEM and X-ray show that metal particle and metal coating NiCrAlY have microstructure, consisting of intermetallic phase ß- $Ni_{1.1}$ $Al_{0.9}$ and cubic phase Cr_2Ni_3. After prolonged precipitation annealing intermetallic phase ß- $Ni_{1.1}$ $Al_{0.9}$ is transformed into a more suitable intermetallic phase ϒ '- Ni_3Al. It was found that based on knowledge of the characteristics of metal powder and applied coating we can designed microstructure and based on that properties of the coating.

5. REFERENCES

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