STUDY OF TRIPLE-LAYER DEPOSITION OF TiC/WC/Ti HARD-PEARLITIC FERRITE CAST IRON OBTAINED BY ELECTRO-SPARK DEPOSITION

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Abstract: *The paper includes an analysis of the characteristics of film - film thickness, chemical analysis, surface quality - of triple electrode deposition TiC, WC and Ti (titanium carbide electrode is used as interface 1, tungsten carbide electrode as interface 2 and titanium electrode as cover: TiC/WC/Ti) on feritic-pearlitic iron support, using the electro-spark deposition method. Pulse electric discharge principle is, adopted for material deposition to establish the connection between the qualities and characteristics of deposited materials and final layer characteristics.*

Keywords: *electro-spark deposition, layers, SEM, EDX, microstructure*

1. Introduction

Obtaining thin films with special properties (wear resistance, corrosion resistance and shock resistance) requires the right choice of filler material in strict correlation with the physical and mechanical properties of support material.

Taking into account that the main objective is to improve the wear behaviour of surface hard layers for the deposition appears necessary to generate multilayer surfaces: anchoring layer of material with comparable properties with surface support layer properties are required.

One of the modern methods of processing materials is the electrical discharge pulse which allows parts of complicated forms and small, by taking material from the work piece surface and forming layer deposition electrode application made of the compact, or by entering the workspace powders or powder mixtures, [1], [5].

Electro-spark deposition is also widely used for its relative low cost equipment required to run this process. The deposition of the coating is achieved by an electrical circuit, which generates sparks between the electrode and the work piece [4].

When optimizing the process of electro-spark deposition, we have to analyze the system electrode–substrate because the phase composition and properties of deposited coatings depend on the type of substrate material [6], [8].

Elements that characterize the quality layers and thin films deposition are: uniformity of layers, adhesion to the substrate, thin layers composition and their depth.

2. Materials and method

2.1. Deposition method

Deposition by electric discharge pulse is a technology that uses electricity stored in the capacitor to initiate a spark discharge between cathode and anode. The high temperature generated by spark lead to partial melting and mixing of the material from the surface with electrode material. During the second electric spark the quantity of molten metal solidifies forming the surface layer. Deposited layer must have a very good adherence to the work piece surface and good chemical and thermal compatibility with substrate and high quality wear and oxidation resistance.

Good use of electro-spark deposition method can be found in the textile industry namely friction cam with skates and gear in looms, which are made of cast iron ferritic-pearlitic. Those support parts, require intense wear resistance and the presence of lubrication is forbidden due to textile fibre contamination. In this context, the deposits that increase wear and corrosion resistance can be realized with electrodes TiC, WC and Ti.

The equipment used to obtain superficial deposition is ELITRON 22 A, [9].

Electro-spark deposition scheme is shown in Figure 1.

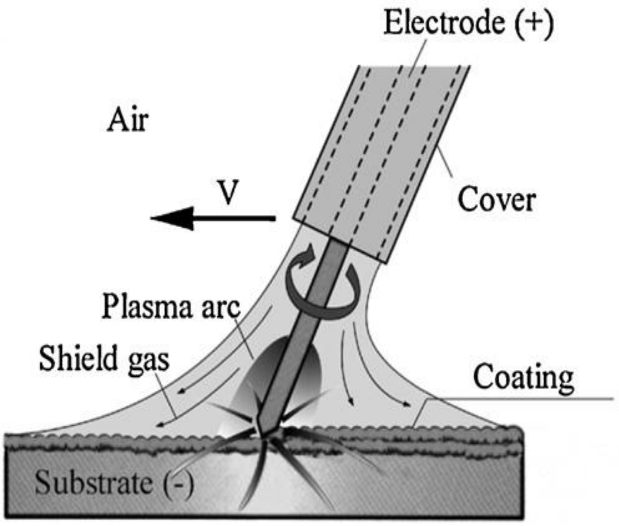


Figure 1: *Schematic of electro-spark deposition process [7].*

2.2. Material characteristics

The material on which the deposition is made is ferritic-pearlitic cast iron. The chemical composition is presented in the table 1, [3] and was determined with Foundry Master Spectrometer. Justification for the choice of the base material is given by its benefits, because it's a material with good thermal shock resilience and requires no lubrication. Also the of expansion and contraction coefficients are small and has the ability to easily take tensions, appearing during work, by the fact that graphite from the matrix create discontinuities, which absorb vibration and shock loads.

Table 1: *Chemical composition for the ferritic-pearlitic cast iron, [%]*

Element	C	Si	Mn	Cr	Ni	Cu
%	3.97	2.87	0.25	0.28	0.12	0.17

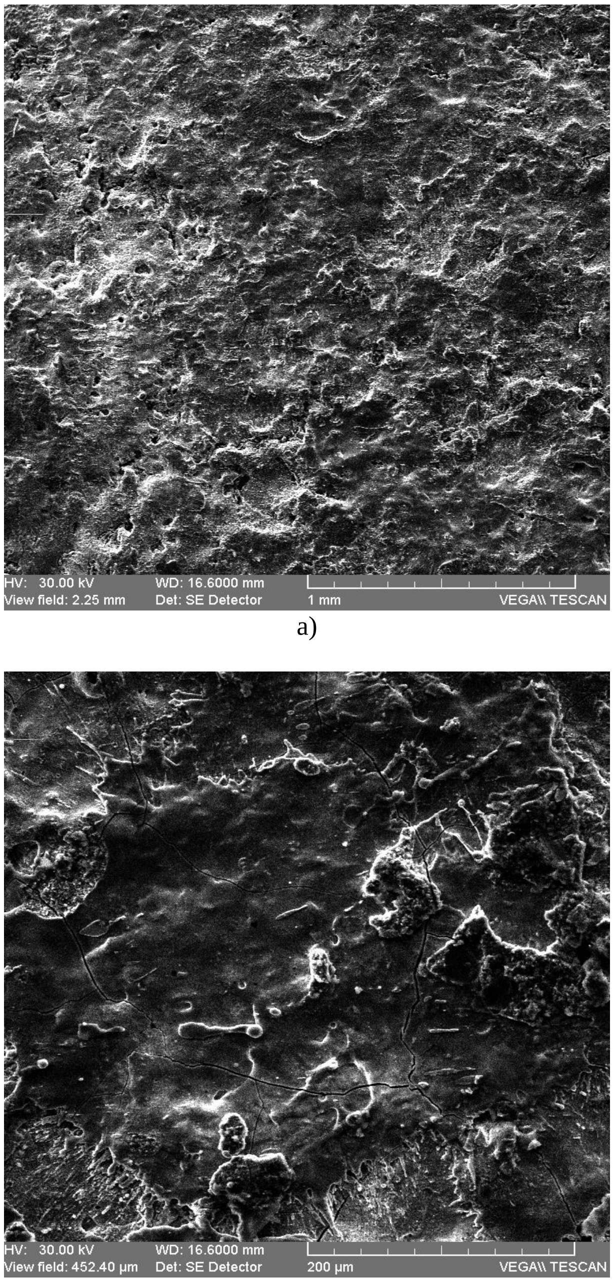
The adding materials are Ti, TiC, and W. Titanium is used for electro-spark deposition because it adheres well to metallic substrate. Titanium carbide is a material compatible with titanium, but also with W and makes a easy transition between the interface and the superficial hard layer. Tungsten carbide creates high surface hardness, improving the wear resistance characteristics of the part.

3. Results and discussion

3.1. TiC/WC/Ti deposition

With Elitron 22A system was made thin layers depositions to modify surface properties of the base material, using the optimal parameters of amplitude and regime.

Surface characteristics analysis was made with scanning electron microscope (SEM), and chemical analysis for the surface layer was made with EDX sensor (Energy Dispersive X-Ray).



a)

b)

Figure 2: *Microstructure of deposit TiC/WC/Ti; a) SE, 1 mm; b) SE, 200 μm.*

TiC deposition interface 1, WC interface 2, Ti coating (Figure 2) was obtained from multiple layers deposited successively by using different electrodes to combine the beneficial features of the exterior piece printed choosing the right sequence.

Studying external appearance of heterogeneous deposition is observed that the relatively smooth appearance with few irregularities and cracks. Titanium carbide successfully takes the unevenness of tungsten carbide deposition and protects the surface of ferritic pearlitic cast iron- of adhesions and peeling made at tungsten carbide deposition. Titanium is used to smooth the roughness of the deposit and tungsten carbide overlays to recast material, observing a relatively smooth surface.

Studying EDX analysis observed the presence of a high percentage of titanium, 39.91%, due to the deposit of the outer layer and his presence in the first interface of titanium carbide deposition.

Table 2. The chemical composition of TiC/WC/Ti layer, %

Element	Fe	C	W	Ti
%	26,04	5,80	32,35	39,91

Tungsten is found in high percentage, 32.35%, due to obtaining a micro alloying in metal bath, which set tungsten into intermetallic compounds and complex carbides resulting in a good distribution. Micrographs are showing the distribution. Titanium distribution is less uniform being located in the area where "drop" of edges can be found. Carbon and iron are uniformly distributed.

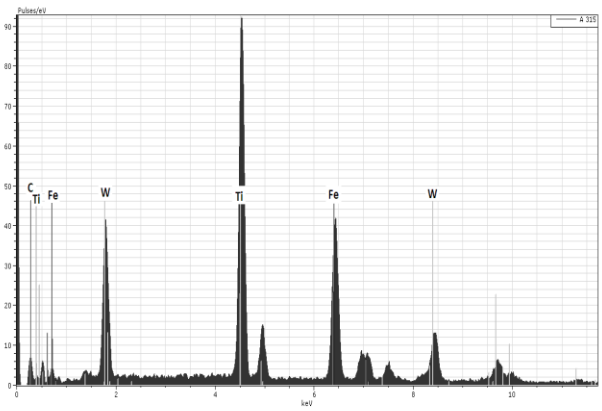


Figure 3: *Spectrum of deposits TiC/WC/Ti.*

Triple layer heterogeneous has properties of technically corresponding because TiC is deposited directly on - ferritic pearlitic cast iron support which has a good adhesion, thermal and structural compatibility with support creating a good base for the next layer (middle layer) given by WC, that adhere better on layer TiC.

Tungsten carbide has a thickness of less than monolayer deposition, so in this case deposited layer thickness not increases.

The external layer of Ti gives a good adhesion and a surface uniform compared to WC, but which dissolving in the micro melting bath creates layers with high hardness.

At triple layer film thickness was analyzed.

In figure 4 is observed surface smoothness and relatively uniform thickness of the layer (thickness is between 70 ÷ 100 m).

Deposited layer thickness is relatively good and constant for the type of deposit. The following crossings uniform the peaks from the first crossings and develop a uniform layer on structure and depth.

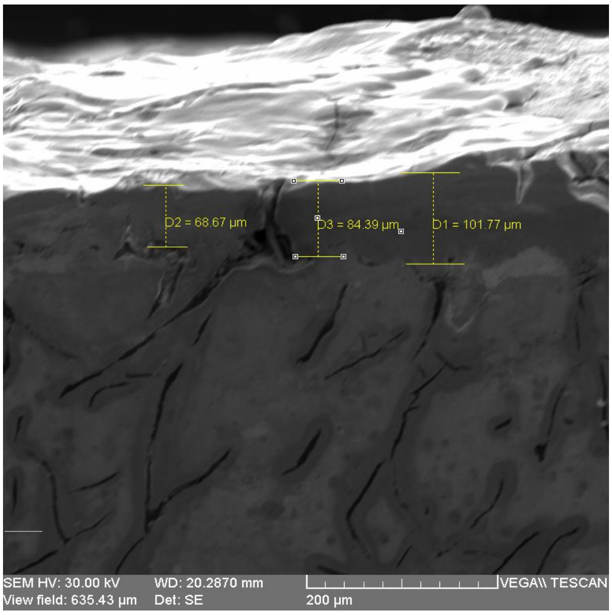


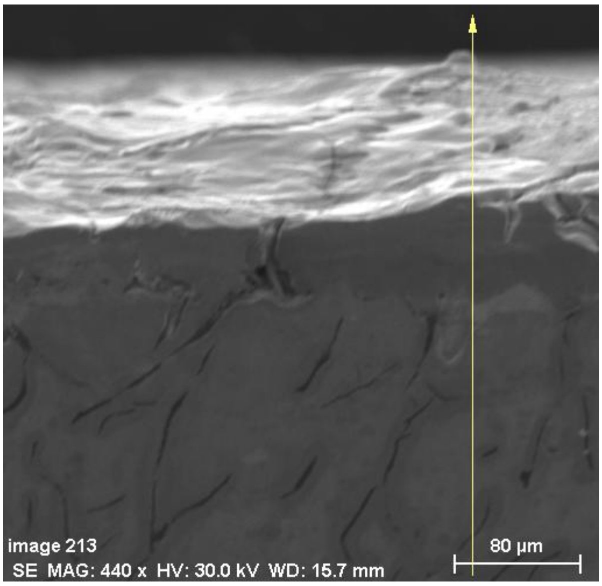
Figure 4: *Layer thickness variation.*

Studying the distribution of elements in the section by EDX analysis it is observed that Ti is mainly based deposit layer, while carbon and tungsten are uniformly distributed on the section.

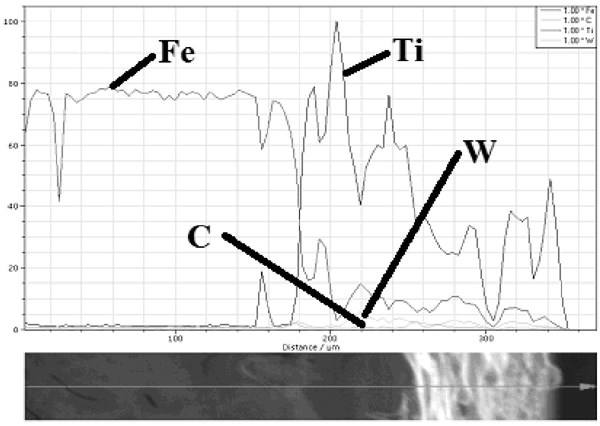
In section iron deposit is found insignificant quantity.

In line analysis (Figure 5) shows the same type of distribution.

Cracks in the layer is observed and primed in the area where a graphite lamella found on cast iron sample surface, lamella area is not adherent to deposited layer (graphite does not dissolve in the metallic micro bath "droplet").



a)



b)

Figura 5: *Line analysis of deposit TiC/WC/Ti; a) SE photography; b) distribution graphic elements.*

4. Conclusions

In terms of metallurgical aspects, for surface triple combination, we conclude that the electrodes of titanium carbide and tungsten carbide have affinity matrix based on ferrites, creating homogeneous layers, but pronounced cracks due to different dilatation coefficients of the material basic. Titanium is used as it creates smooth outer layer, having the role to smooth roughness with deposition of tungsten carbide and recast material overlaps.

The effect is beneficial for subsequent deposit TiC/WC/Ti, because it develops acceptable layer thickness, low roughness, high hardness and uniform deposition on the surface.

Coating thickness is between 70...100 µm. If wants a little roughness, surface layer can be processed by rectification; after removal of material, maintaining the high surface hardness. Surface layer keeps partial effects of deposit (filler material, the diffusion area, ultrafast hardened support).

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