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HARDENING OF THE GREY CAST IRON THROUGH THE VIBRATING ELECTRODE METHOD USING A WC ELECTRODE AND IN COMBINATION WITH TiC AND Ti ELECTRODE

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ABSTRACT

There have been tested samples of grey cast iron, the hardening being made through WC coating through the vibrating electrode method with a layer, two layers and through double layers combined with Ti and TiC. Besides double layers combined there were also made triple combined layers. Afterwards there were taken photographs of macro-hardness and HV50 micro-hardness into the material in into the layer. There were also made rugosity measurements. Then in order to appreciate the internal stresses were made ring specimens type Naimov. On the exterior of these specimens were made coatings with the vibrating electrode.

KEYWORDS*:* vibrating electrode, hardness, coating, combined layer.

1. Introduction

The superficial heat treatments with material supply are domains which interest a lot. Some of these domains are: the surfaces processing with laser beam light, diffusion treatments in plasma, coatings through heat spraying, thin layers deposits through CVD and PVD proceedings.

The alternative methods of deposit on metallic surfaces can be divided according to the technological process:

- coatings through heat spraying which use arc flame, electric arc and plasma;
- PVD coatings (vapor physical deposition) that can be with ionic coating, electron bombing and laser alloying;
- Chemical deposition (CVD).

The vibrating electrode method belongs to the same class with the electric arc coatings. The principle of hardening through electric sparks of the metallic pieces consists in the fact that in case of sparking unloading under the pulsatory current takes place the polar transport of the electrode material, which represents the anode, on the surface of the piece, which is the cathode.

This material alloys the layer of the piece and by chemically combining with the atomic dissociated azotes from the air, the carbon and the material of the piece it forms a diffusion layer which is hardened and resistant to wear. In the superficial layer are formed complex chemical reactions: azotizes, carbonitriding, very stable nitridings and quenching layers.

2. Experimental results

It was used for the experiment the ferrite-pearlite grey cast iron to which the chemical composition is given in the table.

We have chosen the grey cast iron because the study depends on the implementation of the method within the technological processes of the piston rings which are made of cast iron and have a powerful wear on the exterior.

This made us think that we could prolong the life of the piston rings by making this micro alloying treatment. The tests were made on an apparatus type Elitron 22.

Table 1*.The chemical composition of the cast iron specimens used in experiments*

C	Si	Mn	P	S	Cr	Ni	Cu	Mo
[%]								
3.97	2.87	0.25	0.06	0.07	0.28	0.126	0.17	0.03

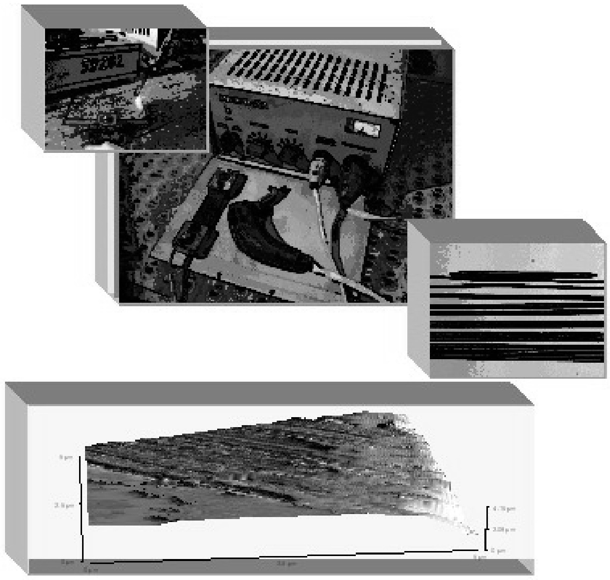


Fig.1*.a) Elitron 22 –the installation for sputtering deposition with different kind of electrodes*
b) Deposition WC one layer(Atomic Force Microscopy).

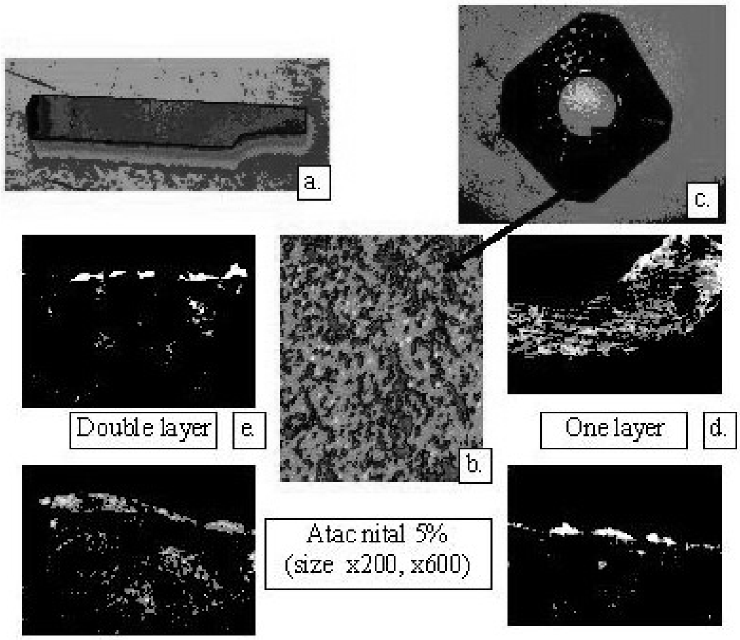
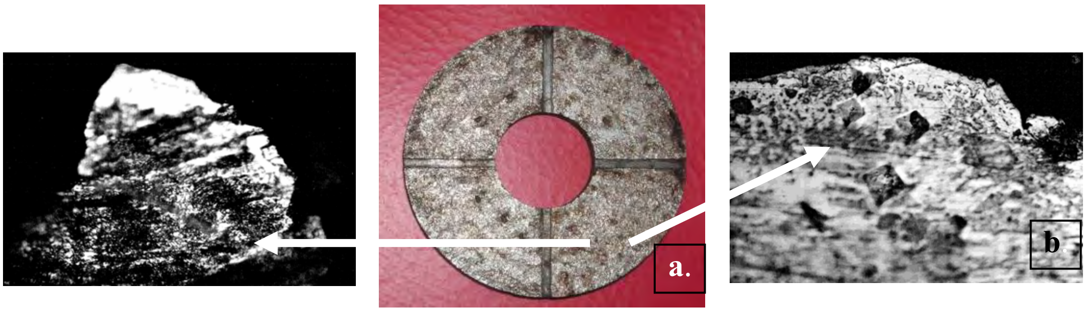


Fig.2*. a. WC electrode; b. Macrostructure surface with WC deposition; c. Cast iron sample with WC deposition by vibrating electrode; d. Microstructure of WC deposition one layer; e. Microstructure of WC deposition double layer.*

There were made tests with layer deposition through sparking with W electrode, with a layer and two layers, but with double layer combined with Ti and TiC. Using W electrode we can observe that it is obtained a compact surface but with pronounced irregularities like in figure 2. The coating had some difficulty degree because the W electrode makes holes and jumps during the surface alloying.

We worked with high amplitude and average intensity (A_6, r_3). All the etchings were made with 5% Nital and the photos were made with a magnification power of x200 and x600. For the combined double layers I used as base Ti because it gave the layer a good compacting and anchor, the deposition was uniform and the WC was on the exterior because it gave hardness to the surface.



Ti base   WC exterior

***Fig.3**. a. Cast iron sample with different kind of deposition-macrostructure; b. Microstructure double layer deposition, first layer Ti deposition and front layer.*

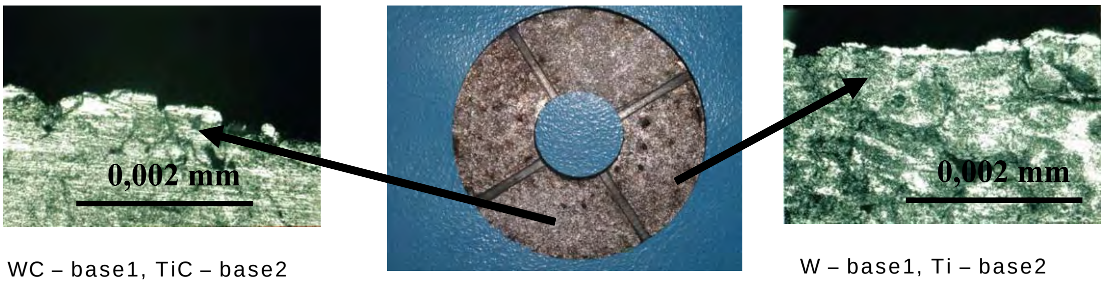
The deposition with Ti base takes to the disparity of the defects like holes and oxides.

We used for the triple combined layers W as base because it has a good adherence on cast iron, Ti as an intermediate layer because it gives the combination a good toughness and on the exterior it was used a WC because it has high hardness.

The second kind of sample was covered with triple combined layer having as base WC because it anchors on cast iron, TiC as an intermediate layer which leads to the extinction of the defects like holes and oxides and on the exterior it was used W which leads to the appearance of a uniform layer.

There was made the micro hardness after the depositions by using the apparatus PMT3. It was used a weight of 50 g in order to press the diamond penetrator.

Making an average to the realized tests, I noticed that we have the hardness much higher than the base material.



WC – base1, TiC – base2
W - exterior

W – base1, Ti – base2
WC – exterior

***Fig.4**. Cast iron sample with different kind of deposition-macrostructure; Microstructure triple layer deposition, first layer W, second layer Ti, WC exterior layer and WC first layer, TiC front layer, W exterior layer*

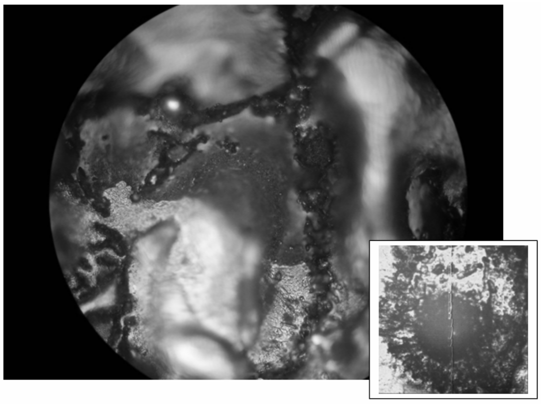


Fig5. *Cast iron sample picture which shows the characteristics of the electrode WC deposition layers; cracks, oxides, surfaces uniformity ; in the corner is placed a drop of WC electrod deposition.*

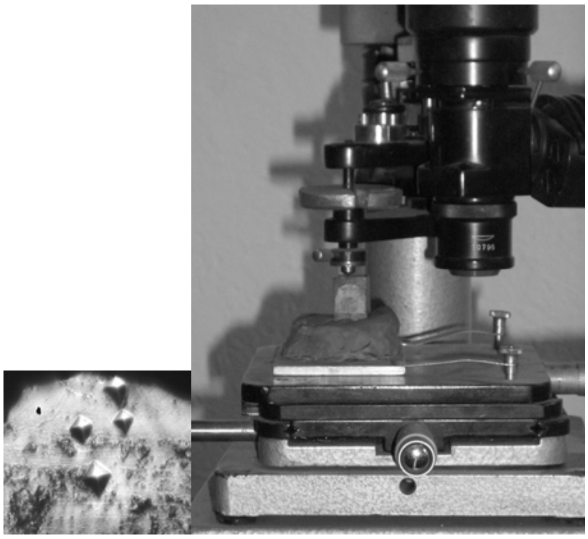


Fig.6. *Apparatus PMT3 for micro hardness measurements.*

To determine the internal stresses there were used test bars type Naimov from grey cast iron.

$$\sigma_f = \Delta_e \frac{Eh^2}{36\pi R^3}\left(\frac{2h}{K(2R-h)} - 1\right) \qquad (1)$$

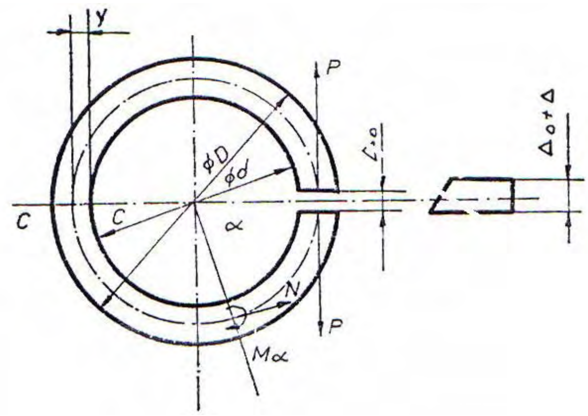


Fig.7. *Test sample Naimov type*

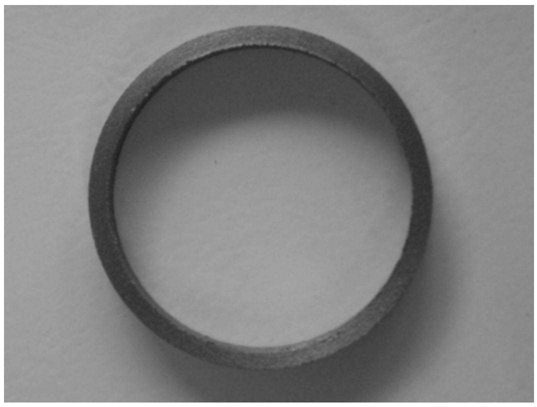


Fig.8. *Test ring Naimov type*

The rings were stress relieving treated to the temperature of 550°C for 3 hours and cooled with the furnace. On the rings there were traced two marks like a cross, the distance between them was measured before and after cutting. The cutting was made after deposition so that the obtained opening is proportional with the size of the introduced internal stresses. We used the calculus from curve girders for the calculus of the stresses.

The introduced stresses are mainly forging, drawing that adds on the value of the existent stresses from the piston rings prolonging their function period.

Table 2.*Variation of hardness in deposition layer*

Base material	WC– one layer	WC – double layer	Ti first layer, WC front layer	W base, Ti second layer, WC front layer	WC base, TiC second layer, W front layer
400	976.56	818.325	566.89	979.42	867.29

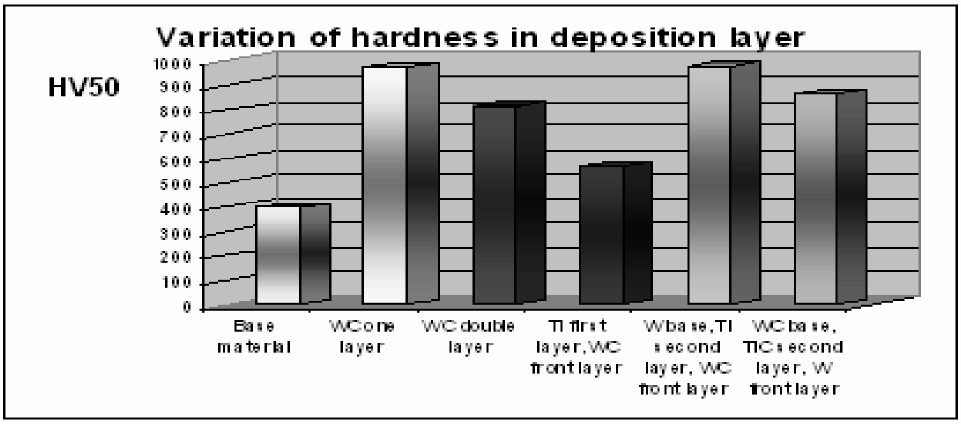


Fig.9. *Graph of hardness in deposition layer*

Table 3. *Variation of the internal stress*

No. rings	Deposition tipe	No. deposition layer	Δ_r [mm]	$\sigma_{rem.}$ [N/mm^2]
I	WC	1	+1.45	115.35
II	WC	2	+0.45	35. 8
III	Ti-b; WC-e	1+1	+0.24	19.09
IV	W-b1;Ti-b2;WC-e	1+1+1	+0.45	35.8
V	WC-b1;TiC-b2;W-e	1+1+1	+0.41	32.61

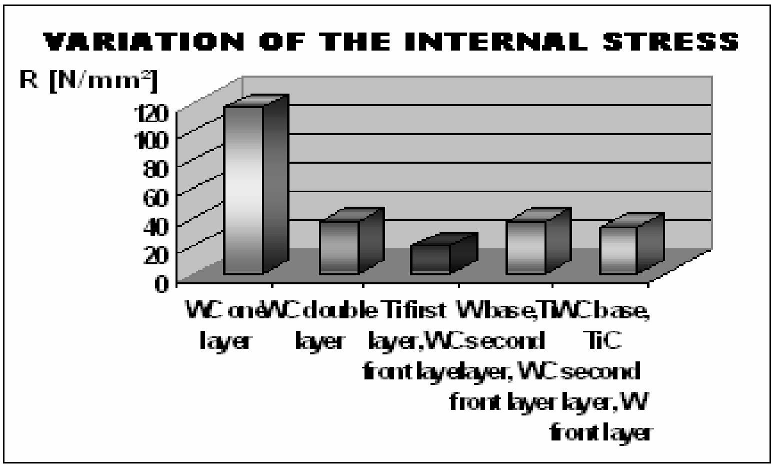


Fig.10. *Graph of internal stress in different deposition layer*

3. Conclusions

1. The method has practical applicability not only for restoring but also for prolonging the function period of the cast iron pieces that work in intense regime like piston rings.

2. From technological point of view it works easier manually with electrodes of different dimensions: 3 - 6 mm diameter and the deposition are more uniform.

3. If we compare the results we can see from the graphs that the micro hardness in deposition layer is almost double the micro hardness of the base material.

4. From tensile graph we noticed that maximum value for tensile stress was obtained using WC electrode one layer and it has 115.35 N/mm^2, and the minimum value was obtained for combined layer Ti base and WC surface layer 19.09 N/mm^2.

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