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Structural Modifications of Superficial Layer of C45 Steel Samples Through WT20 and WZr8 Depositions

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Abstract: The paper presents technological aspects regarding the modification of mechanical chracteristics in the superficial layer of C45 steel samples, through thin layers deposition using WT20 and WZr8 electrodes. Deposition of thin layers was made through electrical discharge method in impulse. The obtained samples were microstructural analyzed, at various magnitudes, on an VegaTescan electronic microscope. Also, measurements of mechanical chracteristics were made through indentation, highlighting the improved values after layers deposition with the 2 electrods.

1. Introduction

The steel presents the posibility of allloying with the most various chemical elements, resulting highly improved properties [1,2].

The carbon steels contain beside iron and carbon, other alloying elements. Other chemical elements are considered impurities. The exception from this rule are some elements, which are imposed by the technological process of elaboration and casting (manganese, silicon, aluminium).

The regular steel carbon is manufactured curently and used without heat treatments at civil constructions, metallic constructions and machines facturing.

The quality carbon steel is used in machine manufacturing, usually heat treated and has guaranteed chemical composition and mechanical characteristics.

The superior carbon steel is a quality steel in which the content of sulfur and phosphorus is limited at below 0.035% each and conditions are imposed regarding the structure (size of austenitic grain, depth of hardening) and the maximum content in non-metallic inclusions.

Low alloyed steels are steels which contain alloying elements willingly introduced in mininum quantities which influence the physical-chemical properties and mechanical characteristics.

The alloyed steels are the medium and high alloyed and are used only heat treated. The alloyed steels have the sum of alloying elements concentrations higher than 10% or one of this concentration higher than the following limits: Si 6%; Mn 6%; Cr 6%; Ni 4.5%; Mo 1%; W 4%; Co 1%; V 1%.

The steels are delivered to the beneficiaries in the form of cast parts or laminated: blooms, slabs, wires, billets, sinkers, round steel, square, hexagonal, flat, profiles, thin sheets, plats, strips [8].

Table 1. Influence of alloying elements on steel properties [8].

Silicon	Increases the corrosion resistance Has deoxidizing effect
Manganese	Increases hardenability Increases hardness Increases tensile strength Increases the resistance at abrasive usage
Chrome	Increases the mechanical resistance Increases thermal stability Increases the corrosion resistance Increases the resistance at abrasive usage
Nickelum	Increases the static and dynamic tenacity Increases the corrosion resistance and refractarity
Molibdenum	Increases hardenability Increases mechanical resitance Increases the stability at temperature Increases the dynamic resilience Increases the corrosion and rupture resistance
Vanadium	Increases the mechanical reistance Increases the plastic deformability Forms carbides, nitrides, oxides Favorizes the fineness of structure Increases hardenability
Tungsten	Increases hardness Increases refractarity Increases the mechanical resistance and hardenability Forms hard carbides, resistant at abrasive usage
Cobalt	Increases hardness Decreases the adherence at rapid machining
Aluminium	Deoxidyzing Eases the hardening of the grain at nitriding
Titanum	Deoxidyzing Reduces the sulphurs Forms hard and refractary carbides
Bor	Increases the hardening of low carbon steels
Copper	Increases the corrosion resistance Increases the mechanical resistance
Tin	Increases the machining

2. Deposition of thin layers through electrical discharge in impuse method

The deposition of layers through electrical discharge on Fe-C alloys are based on electroerosion phenomena and polar transfer of electrode material to the metallic parts. Through the proximity of the electrode to the part, at the critical distance of puncture, electrical discharge through impulse is triggered [3,4,7]. Due to polar effect, the transfer of electrode material to the part assures the forming of the superficial layer, with highly determined physical-chemical properties. As a result of the material transfer and thermal modification from the discharge area, the superficial layer of the part is modifying the structure and the chemical composition. The characteristics of this layer can variate in high limits according to the electrode material, the environment composition between electrod and part, the parameters of impulse discharging. The superficial alloying, realized through layers deposition with electrical discharge method, can have the following purposes [5,6,7]:

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- Increasing the resistance properties
- Increasing the thermostability
- Increasing the corrosion resistance
- Increasing the mechanical and electrical properties
- Increasing the steels hardenability
- Changing of electrical and magnetical properties

3. Experiments

3.1. Determination of chemical composition through spectral quantitative analysis
The analyze of chemical composition was made on prepared samples through polishing, using an Foundry Masters optical spectrometer, type 01J0013. With WasLab software and calibration programs, has been obtained a analysis bulletin, which present the values determined by the apparatus.

Table 2. Chemical composition determinate through spectral quantitative analysis.

Fe	C	Si	Mn	P	S	Cr	Ni	Mo	Al	Cu
97.8	0.62	0.25	0.59	0.013	0.072	0.12	0.16	0.026	0.07	0.17

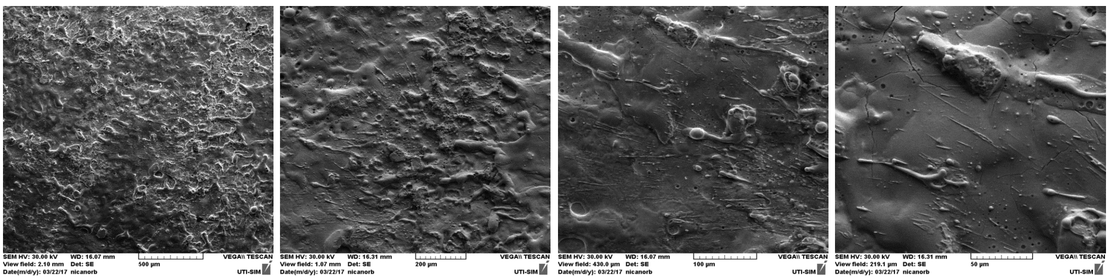
The analized sample is part of steel class, mark C45.

3.2. Superficial processing through electric discharge with compact electrodes
As hardness measured values after the improving treatment are low, on the normalized samples thin layers were applied using Elitron 22A apparatus, through electrical discharge method. For the experimental attempts, 2 tungsten electrodes were used, having different compositions (table 3).

Table 3. Composition of electrodes used in the experimental attempts.

Designation	Composition			
	Dioxide	Dioxide in %	Impurities %	Tungsten
WT20	ThO2	1.70 – 2.20	< 0.20	Remainder
WZr8	ZrO2	0.70 – 0.90	< 0.20	Remainder

3.3. The structure analysis of superficial layers
After the WT20 and WZr8 layers deposition, were made SEM photos at 100x, 200x, 500x, 1000x magnitudes (figures 1, 2), [9].



100x 200x 500x 1000x

Figure 1. The aspect of WT20 deposited layer on C45 steel.

From metallographic photos achieved through electronic microscopy, at different magnitudes, it can be observed that in the case of WZr8 deposition, the layer is more uniform, and in case of WT20, the surface formed structure are smoother.

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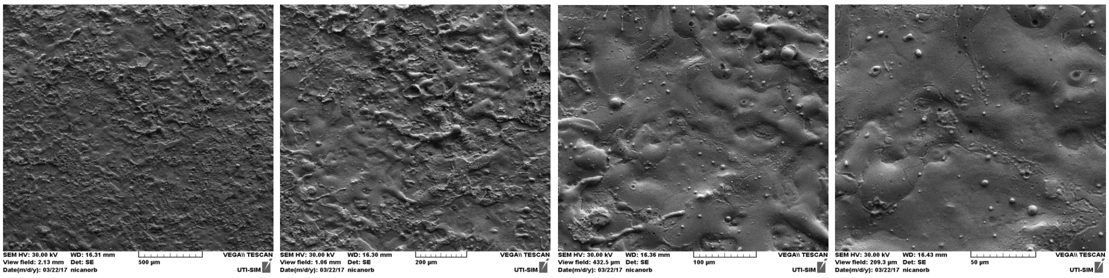

100x 200x 500x 1000x

Figure 2. The aspect of WZr8 deposited layer on C45 steel.

3.4. Measurements of mechanical characteristics at the superficial layer level

The determination of mechanical characteristics was made on CETR-UMT2 microtribometer. Hardeness and Young modulus modifications were analized.

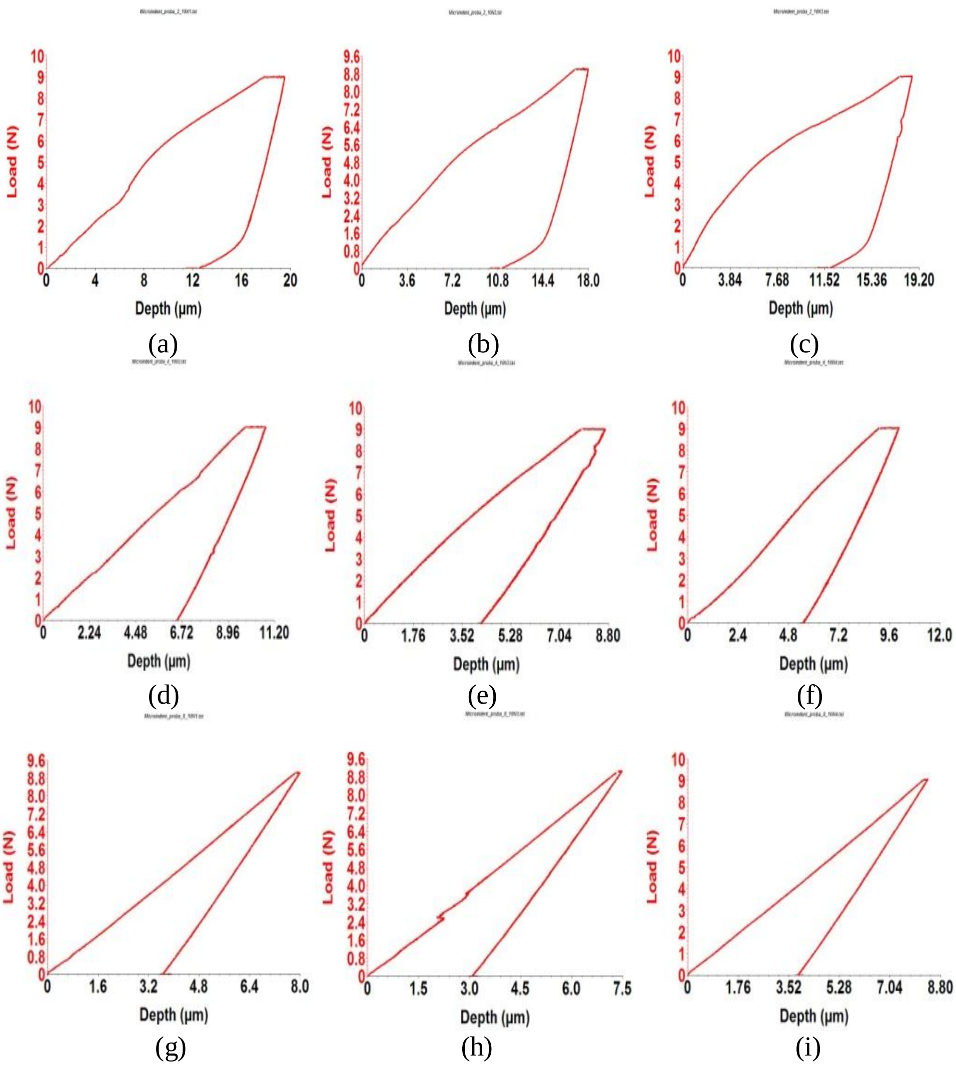

Figure 3. Aspects of microindentation curves for base material (figures a, b, c) and WT20 (figures d, e, f) and WZr8 (figures g, h, i) deposited layers.

The analized samples had small dimensions (according with the requirements of apparatus manufacturer) and were prepared in advance (without oxides or other substances resulting from previous machining). The achieved layers through depositions with WT20 and WZr8 electrodes, were presented with different structures and their hardness average is improved against the obtained values for the basic material (C45 steel).

Table 4. Measured values of mechanical characteristics.

State	Nr.	HV (Gpa)	Average	Young (GPa)	Media
Based material C45	1	0,427483	0,451694	18,125	17,918
	2	0,471523		18,273	
	3	0,456076		17,357	
Deposition with electrode WT20	1	1,317432	1,203496	22,300	21,475
	2	1,271933		21,955	
	3	1,021125		20,170	
Deposition with electrode WZr8	1	1,451079	1,508652	23,673	22,863
	2	1,662807		24,185	
	3	1,412071		20,732	

In the case of Young modulus there is a 25% increase in measured values for deposited layers (WT20 and WZr8) compared to the base material (steel C45).

4. Conclusions

The mechanical characteristics of the superficial layers can be improved by superficial alloying, using the electrical discharge method and electrodes that have chemical elements in the composition with a modifying role (according to table 1). The samples used in the experimental test are part of C45 steels (table 2 – quantitative spectral analysis bulletin), and the two electrodes were based on tungsten, with different compositions (WT20 and WZr8 – table 3). Superficial layer structures were analyzed by electronic microscopy at different magnification powers and it can be seen that in case of deposition of WZr8 the layer is more uniform (figure 1), and in the case of WT20 deposits, the structures formed on the surface are finer (figure 2). The HV hardness measured on the deposited layers has values superior to the base material (steel C45). The increase is in the range 250 ... 300% (according to table 4). Young modulus shows an increase of approximately 25% of the measured values for layers deposited (WT20 and WZr8) compared to the base material (steel C45).

References

[1] Muralidharan B, Chelladurai H, Praveen S et al. 2016 *Materials And Manufacturing Processes* **31** 1853-1864
[2] Moscicki T, Radziejewska J, Hoffman J et al. 2015 *Ceramics International* **41** 8273-8281
[3] Salih D, Salim Levent A, Kemal K 2015 *Acta Physica Polonica A* **127** 1410-1413
[4] Alexandru A, Carabet R G, Carcea I 2008 *Metalurgia International* **13** 18-22
[5] Țugui C A, Nejneru C, Galușcă D G, Perju M C, Axinte M, Cimpoeșu N, Vizureanu P 2015 *Journal Of Optoelectronics And Advanced Materials* **17** 1855-1861
[6] Vizureanu P, Perju M C, Galușcă D G, Nejneru C, Agop M 2010 *Metalurgia International* **15** 59-64
[7] Gălușcă D G ș.a. 2011 *Tratamente termice – îndrumar de laborator*, Editura Tehnopress
[8] Alexandru I, ș.a. 1995 *Alegerea și utilizarea materialelor metalice*, Editura D.P, București
[9] Perju M C, Tugui C A, Nejneru C, Axinte M, Vizureanu P 2016 *IOP Conference Series-Materials Science and Engineering* **133** 012025