Experimental Researches by Applying Sonic Surface Treatments to Carbon Steels

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Abstract— The paper presents some experimental results obtained by applying sonic surface treatments to carbon steels plastic deformed or cast. The goal of these tests is to obtain the increase of the performances of some materials that are at higher level used in industry. The method used was ion nitriding and thin layer deposition of TiN which have been developed on a large scale.

Keywords— heat treatment, plasma, steel performances, corrosion resistance

I. INTRODUCTION

THIS increase of parts durability, of the machine tools and equipment represents today a problem of special interest world - wide. The high costs of row materials and energy determine the necessity of finding some solutions in order to increases resistance and durability of pails.

The studies and prognosis show that the surface heat treatments in plasma will meet most successfully these requirements.

The most important are die ion nitriding and thin layer deposition (usually TiN) which, offering special properties for work conditions, have been developed on a large scale.

Of course, high performances are possible only using adequate steels (low alloyed carbon and even high alloyed carbon steels), and only applying preliminary heat treatments which to assure both appropriate properties for the core of the parts and adequate support for the obtained layers.

The experimental tests, which represent the goal of this paper, refer to the plastic deformed or cast steels, which hold a high use percentage in machine construction. The surface deposits lead to higher properties in layers and to higher wear, fatigue and corrosion resistance.

Due to the low values of hardness, in technical literature, the behavior of these steels at ion nitriding or TIN covering is hardly mentioned. In industrial practice, in last period these are the steels aiming to be at a higher level used.

II. THEORETICAL CONSIDERATIONS

Ion nitriding is based on the glow discharge in rarefied gas principle and leads to the ion acceleration under potential difference. These heats the cathode surface (the pails for ion nitriding) tear electrons. After crossing of a short distance, the primary electrons achieve the necessary energy for gas molecules ionizing, getting to the plasma stage, which provides the saturation substance for treated surfaces.

Correlating the current and the discharging voltage, as well as the value and the gas composition, between the treated surface and plasma particles, exchanges of energy take place, favoring the ferrous nitrides obtaining, as a result of cathode pulverization. At the surface of the treated parts a white layer appears (combination zone) and a diffusion layer.

The obtaining of hard layers through physical vapor plasma deposition (Pa PVD) represents another very large used method. In this case, the layer is formed by metal particles obtained directly through vaporizing, wide react directly with the working gas. In the case of TIN covering, the plasma gas is argon, caring gas is nitrogen and the target is manufactured from titanium with 99, 9% purity. From the surface of the Ti plate, with the help of an electric arch, the ripping and vaporizing of metal particles take place these being strongly orientated and accelerated into a ionic-plasma cloud. Through the loading with negative load of the retaining device of the parts, the titanium vapors are with high speed orientated to the pieces, which followed to be covered.

III. RESEARCH METHODOLOGIES

The experimental research was made on two types of carbon steels very often use in machine construction: OLC45 and OT50 both cohering a closed chemical composition.

The samples used for experiments have been manufactured by plastic deformation (in the case of OLC45) or by casting (in the case of OT50). The chemical compositions of the steels are presented in the Table 1.

Table 1. Chemical compositions of the steels

Steel	Chemical composition [%]				
	C	Mn	Si	S	P
OLC50	0,46	0,70	0,25	0,035	0,030
OT40-1	0,42	0,75	0,30	0,025	0,025

From the steels, prismatic samples have been manufactured. After applying different heat treatment variants they were tested at wear, fatigue and corrosion. The preliminary treatment, for a

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group of samples was normalizing from 850°C with air-cooling. For the other lot was improving (hardening) from 810°C and cooling in water and tempering at 580° C with cooling in water.

From the both lots, same samples were ion nitrogen and some of them covered with TIN. The equipment used for ion nitrogen was an I.N.1.70, having the following characteristics: absorption, power of the discharge 64 KW during the heating and 32 kW during covering with nitrogen, the maxim voltage 800 V, the discharge of ammonia 10 Ni/h at maximum weight of the charge of 1500 Kg.

In the case of ion nitriding different variants were tested using heating temperatures of 530^0, 550^0, 580° C and maintaining duration at the temperature of 5h, 8h and 12h.
An optimum variant has been established, from the point of view of nitrided layer macrostructure and the obtained hardness.

As result, a part of the samples treated through this variant were covered with TiN. The covering with TiN was realized on a special equipment type MCTAI.Pf.ANT-MR 323 in the following conditions: cleaning 70 min, at current of 90A and 250V, discharge in argon 6 nr/s, deposing of TiN through discharge in nitrogen 270 cmVs at 270A and 320V.

The micro-hardness have been determined with a Vickers equipment, using a weight of 0.050 Kgf in the case of layers obtained through ion nitriding and 0,020 Kgf for the layers obtained through by covering with T I N .

The hardness of the core has been measured using equipment, having the load of l87.5 daNf and a sphere of 2mm diameter.

The thickness of the "combination" layer has been estimated with the help of an ocular micrometer and for the diffusion zone, comparing with the hardness at the surface.
The layer fragility has been estimated after the aspect of the print, obtained with a diamond pyramid from Vickers equipment having in view the great number of experimental results in this paper will be presented only aspects regarding the microstructure and the hardness obtained in surface layers after applying different variants of surface treatments. Tire fatigue, wear and corrosion resistance will represent the main objective for another paper.

IV. EXPERIMENTAL RESULTS

In Tables 2 and 3 are presented the results obtained through ion nitriding in different technological variants, from the point of view of hardness and the thickness of the surface layers, for two types of studied steels, after "normalizing" (N) and "improving" (I) as preliminary treatments.

Considering the obtained result for die presented technological variants, as we expected, the increasing of nitrogen temperature and duration of maintaining at temperature lead to an improving of hardness in the same time with an increasing of the thickness for combination and diffusion layers.

Interesting results were obtained in the case of OT40-l carbon steel from the point of view of thickness of diffusion layer, even if the hardness in surface layer was a bit smaller.
In the Fig.1 are presented the microstructures obtained by covering with TiN (at 400°C/30min.), directly on improved samples and after ion nitriding at 550° C/8h.

The thickness of the layer obtained in the first case is about 0, 5 μm and in the second case about 8 μm.

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Table 2. Hardness and thickness of surface layer

Nitriding duration	Features obtained on applying ion nitriding of OLC50 carbon steel	Nitriding temperature [^{0}C]					
		530		550		580	
		Initial treatment					
		N	I	N	I	N	I
5h	Hardness [HV5]	310	350	330	390	360	430
	White layer [μm]	-	4	-	6	-	8
	Diffusion zone [μm]	20	45	30	65	75	90
8 h	Hardness [HV5]	321	370	340	420	375	480
	White layer [μm]	3	5	4	8	5	10
	Diffusion zone [μm]	40	60	50	80	75	100
12 h	Hardness [HV5]	330	410	365	450	390	510
	White layer [μm]	4	7	6	9	8	13
	Diffusion zone [μm]	50	80	70	100	110	120

Table 3. Hardness and thickness of surface layer

Nitriding duration	Features obtained on applying ion nitriding of OT40-1 steel	Nitriding temperature [^{0}C]					
		530		550		580	
		Initial treatment					
		N	I	N	I	N	I
5h	Hardness [HV5]	270	315	295	330	315	375
	White layer [μm]	-	2	-	5	-	7
	Diffusion zone [μm]	30	65	40	80	55	100
8 h	Hardness [HV5]	290	350	315	370	325	425
	White layer [μm]	-	4	3	7	5	9
	Diffusion zone [μm]	50	80	65	95	80	115
12 h	Hardness [HV5]	320	380	340	420	360	460
	White layer [μm]	3	5	5	8	6	11
	Diffusion zone [μm]	60	100	80	115	120	145

Fig.l. Microstructures obtained after TiN covering: a) improved samples; b) improved and ion nitriding at 550°C/ 8h samples (250x).

In Figs.2 to 4 are presented the microstructures obtained at three different technological variants applied for normalized and improved samples of OLC45 carbon steel.

The chosen nitriding variants were: 530°C/5h; 550°C/8h; 580°C/5h for representing the temperature and maintaining duration influence on microstructure and hardness. For the carbon steel OT50-1 the microstructure are sensible the same, only hardness and thickness of surface layer being different (Table 2).

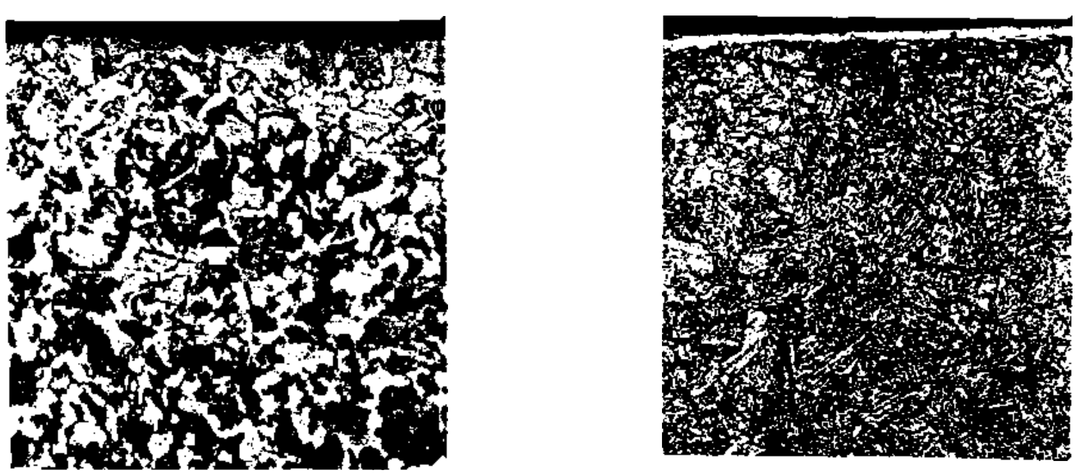

Fig.2 Microstructures obtained after ion nitriding at 550°C/5h (250x).

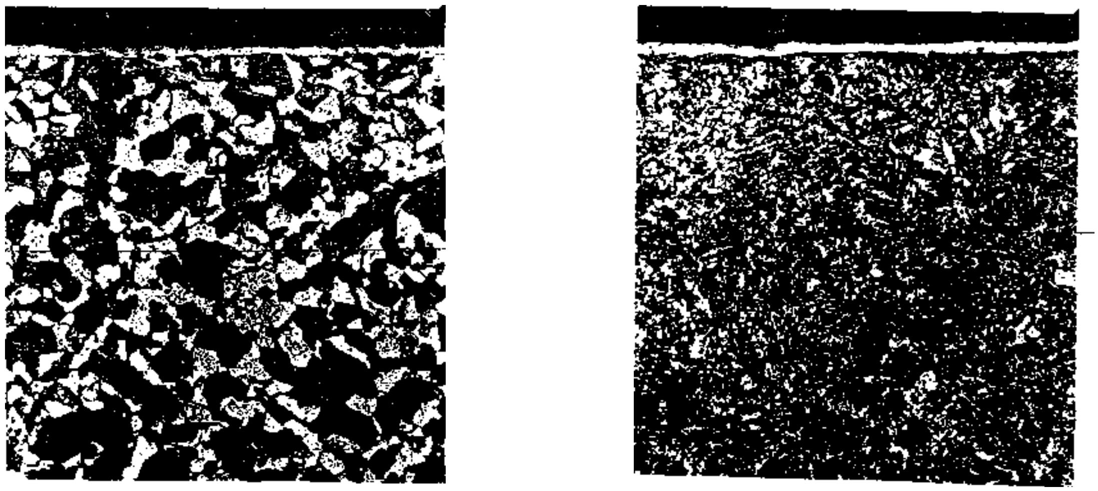

Fig.3 Microstructures obtained after ion nitriding at 550°C/8h (250x).

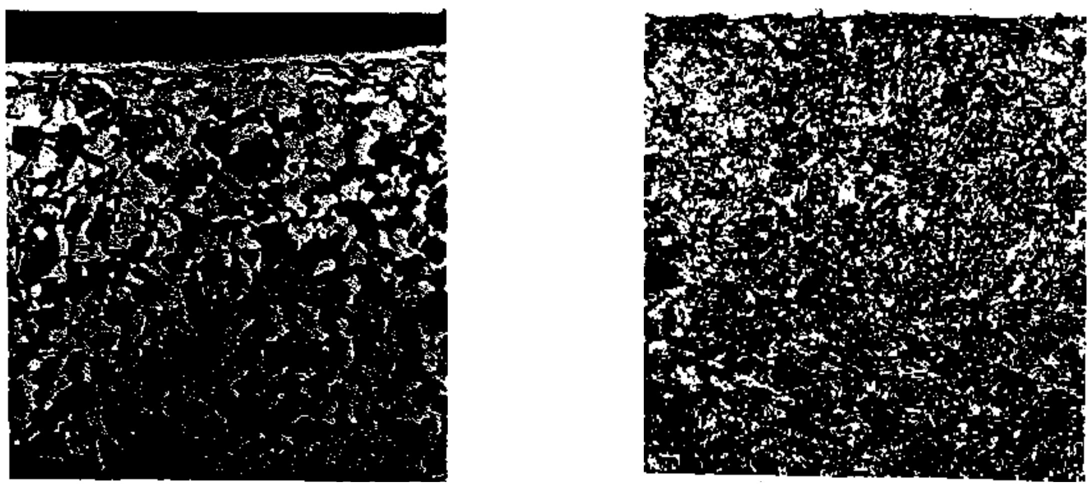

Fig.4 Microstructures obtained after ion nitriding at 580°C/8h (250x).

Having in view that the thickness of the layers obtained at covering with TiN on samples improved was under 1μm, the measurement of the hardness in the surface layer was obtained under a load of 0,020 Kgf, for avoiding the surface breaking through. Even the print aspect didn't indicated the existence of fragile layers, the low hardness confirm the necessity of a hard under layer for applying of different technologies.

V. CONCLUSIONS

The paper presents a preliminary step from the point of view of applying of some technological variants, pointing surface heat treatments for some non alloyed steels, with the goal of behavior improving for different tests. In this step were studied the microstructures and hardness obtained after ion nitriding, TiN covering and a special heat treatment (ion nitriding and TiN covering. In the second step we are going to make wear tests, fatigue and corrosion resistance tests.

Considering this first step we are able to conclude the following:

- The using of ion nitriding treatment for carbon steels leads to an increasing of the hardness in the surface layers determined. This increasing is dependent on increasing the duration of maintaining at temperature.

This increasing was observed both to the normalized samples and to the improved samples, for the both categories of carbon steel, due on a hand to the nitrogen diffusion in ferrite, and on the other hand to increasing of the thickness of the diffusion zone, in another way. In the case of samples for which the preliminary heat treatment was normalizing, the obtaining of combination zone reclaims temperatures higher than 550°C.

For the samples manufactured from cast steel, in the same nitriding conditions, the diffusion zone is bigger than the samples obtained through plastic deformation.

- The covering with TiN can not be capitalized from the point of view of hardness increasing, but only from applying of hard layers.

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