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PLASMA NITRIDING AS TREATMENT FOR IMPROVEMENT OF WEAR PROPERTIES MACHINE PARTS

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Abstract: *Samles of hot work tool steel C.4751 (En-X37CrMoV51) from various previous heat treatments are nitrided in the glow discharge plasma of gas mixtures H_2 /N_2 at the temperatures from the interval (500-550)^o C with the durations of (6-30)h. Surface hardnesses of around 1100 HV O.3 and nitrided zone depths of (0.05-0.3)mm are achieved. Optimal choice of plasma nitriding parameter set has been achieved in order to form monophase γ'-Fe_4N compound layer on the surfaces of treated components. This layer is thinner than 10 um and it is nearly independent of process time duration. The plasma nitriding parameters set in order to get nitrided layer without any compound layer has been realised, too. The surface roughness of the treated components is slightly enhanced on both grounded and turned surfaces.*

Keywords: *Plasma nitriding,wear, tool steel*

1. INTRODUCTION

Tool steel C.4751 (Utop Mo 1, En-X37CrMoV51) to work in hot condition is very commonly used material for building tools for casting and extrusion. These material is often nitriding before using in such applications. Treatment with conventional gas nitriding in NH_3 lead to the formation of compound layer that is in terms of mechanical and thermal shock tends to cracking. Therefore, this type of layer must first be removed, so the operation requires additional processing which can be very hard, because the tools is often very complicated. Removal of the connective zone is significantly reduced resistance to adhesive wear of nitride devices, which causes problems related to the material. Technology plasma nitriding provides a satisfactory solution to these problems, and it mainly thanks to formation mono-phase thin compound layer type γ'-Fe_4N which is not porous and has sufficient resistance to cracking under conditions of mechanical and thermal shock.

The process of plasma nitriding belongs to the surface hardening group of steel and include the implantation energetic nitrogen ions in the surface layer that is thinner than 10 μm, where it is introduced into the deeper layers of the surface by diffusion process. Electric gas discharge at pressures of order mbar and serves as a source energetičih ions as an energy source for the implementation of high-temperature diffusion process. Basic data about unit where plasma nitriding is discussed in this paper gives enough details to work [1], while the manner of keeping the flow of plasma nitriding process conducted in a similar way to that which is detailed in article [2].

The main reasons for the application of plasma nitriding are: (i) to obtain high surface hardness, (ii) increase resistance to wear, (iii) improving the dynamic properties of materials, (iv) increase corrosion resistance (except stainless steel), (v) obtain surfaces that are resistant to softening effect even at temperatures slightly lower than the nitriding temperature, (vi) to obtain better surface layers of distortion and without dimensions changes of the components, and (vii) obtaining mono-phase nitride compound layer on the surface type ε or γ', and without obtaining nitride compound layers . The aim of this paper is to demonstrate the possibility of realizing some of the above-mentioned properties of tool steel C.4751 to work in hot condition.

2. EXPERIMENTAL

Samples of hot work tool steel C.4751, were heat treated to hardness of (400-500) HB, and they were shaped tiles measuring 50 x 10 mm. One of the base surface ones was polished to the roughness of Ra = 0.25 to 0.30 μm, while the other base grated to the roughness of Ra = 0.4-0.6 μm. The samples were nitrided, 5-30h, in a gas mixture H_2/N_2 different composition at temperatures in the range (500-550)^o C . After nitriding the samples were measured roughness, surface hardness, microhardnesses depth profile and was also made analysis of nitride zone microstructure.

3. RESULTS AND DISCUSSION

Figure 1 shows the microhardness-depth curves of samples plasma nitrided steel C.4751 in gas mixture H_2/N_2 at a temperature of 5000 ^{o}C and (60-30) h. Reached the surface hardness of about 1100 HV 0.5 and a depth of about 0.2mm. Figure 2 shows the microstructure of surface compound layer samples of steel C.4751 plasma nitrided in gas mixture H_2/N_2 . The nitrided layer consists only of the diffusion zone, and after such a long plasma nitriding of 25h at a temperature of 500 ^{0}C. The main mechanism for the formation of such layers can be explained is the sputtering of surface layers, ie. eject surface atoms into the vacuum as a result of interaction energetich beam of ions with the first few monoatomic layers of the sample that nitrided in plasma. By varying the process parameters, especially gas mixture actually varies the sputtering coefficient, given the fact that the coefficient of sputtering isfunction and energy and type oincident ions.

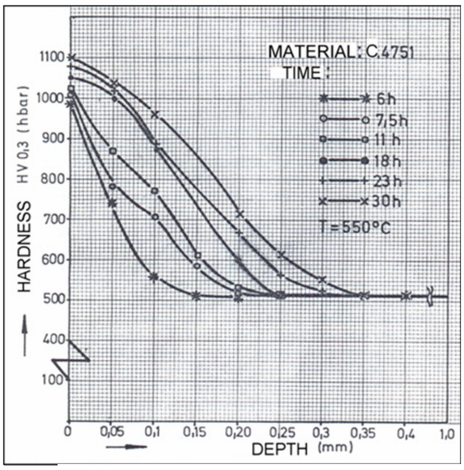

Figure 1. Microhardnesses depth profile of hot work toolsamples steel C .4751 plasma nitrided in gas mixture H_2/N_2.

The microstructure of the surface compound layer of steel samples C.4751 nitrided 6.5h in plasma gas mixture H_2/N_2 at a temperature of 500^0 C and the conditions under which non formation of diffusion zones,shows fig.3. This figure is as proof that the absence of compound layer can not be attributed to a simple spattering previously created compound layer, for example, at the end of the nitriding process, but that in our experiment shalt conditions under which there is a continuous straight balance between these two mutually opposing effects of growing connective zone and its degradation sputtering.

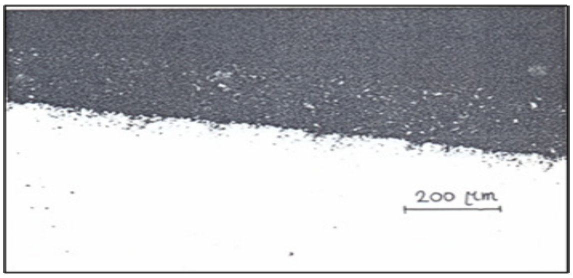

Figure 2. Microstructure of surface layer samples of steel C.4751 plasma nitrided 23h in gas mixture H_2/N_2 under the conditions formation diffusion zone-without compound layer

As a next and final argument to this statement serves Fig.4, showing the microstructure of surface compound layer samples from C 4751 plasma nitrided in the gas mixture H_2/N_2 for a period of 7.5h, at the temperature of 500 ^{0}C, but under conditions in which formed mono-phase compound layer type γ'-Fe $_4$N, a thickness of about 5 mm.

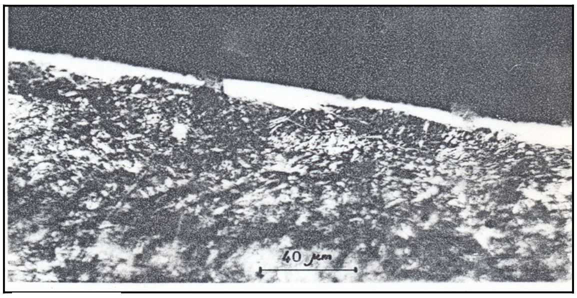

Figure 3. The microstructure of the surface layer of tool steel C.4751 samples plasma nitrided 6.5 h in gasmixture H_2/N_2 under the conditions of formation of diffusion zone only

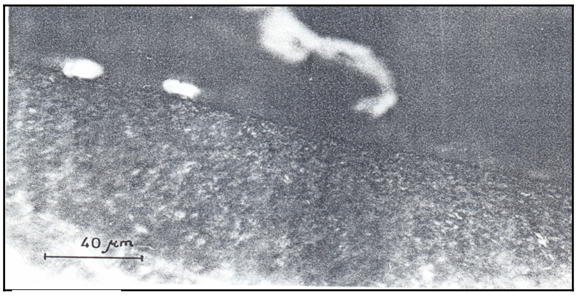

Figure 4. The microstructure of the surface layer of tool steel samples, C.4751, plasma nitrided 7.5h in gas mixture H_2/N_2 under condition formation mono-phase compound layer type γ'-Fe_4N

Roughness measurement results show that the surface quality of the samples plasma nitrided slightly lower than the initial state. Surface roughness Ra after nitriding is 0.30 to 0.45 μm to the previously ground surface (with an initial Ra = 0.25 to 0.30μm), and (0.6-0.8)μm previously grated surface (with initial Ra = (0.4 -0.6) μm). there was no significant differences in roughness between the nitrided surface with or without the mono-phase γ'- compound layer.

4. CONCLUSION

On the base obtained results it can be said:

1. The choice of plasma nitriding parameters enable formation g` or e compound layer or nitridded zone without compound layer on the surface treated components.
2. Plasma nitrided samples of hot work tool steel in gas mixture H_2/N_2, give the compound layer which hardness is 1100 HV 0.3, and the depth of nitriding 0.05-0.3 mm. This compound layer-g` give good resistance to wear, to corrosion resistance and resistance to softening at high temperature of tool.
3. The surface roughness of treated samples is slightly enhanced on both grounded and turned surfaces.

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