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CARACTERIZATION OF THE IONIC NITRING IN THE PROCESS APPLICATION ON 12% Cr STEELS FOR TOOLS AND COLD DEFORMATION DEVICES MANUFACTURING

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Abstract: *The ionic nitriding found a good application in the treatment of cold deformation devices that, because of the hard work conditions, must stand complex loads and show superior phzsico-mechanical properties. For example, the working rolls of plate cold rolling mills must stand loads with specific tensions of 1000-2000N/m^2, must present hardness of 60 HRC, a very good toughness (a high rotatingb bending fatigue strength), must stand to outstanding dynamic tests (impacts, torsion) and must present a high wer hardness and outstanding tribological properties. The good behaviour in exploitation of these devices is conditioned by severe adjustments, high dimensional accuracy and the absence of clearance in gear system, reason for that the dimensional restrictions to the manufacturing of deformation devices are very exigent. So, for cold working are used special high-speed steels, maraging steels and very often (being more accessible) steels with 12% Cr. This article analyses the possibility of applyng the ionic nitriding to steels with 12% Cr, referring to VMoC120, pursuing the way of hardening by this supplemental treatment the working surface of the deformation devices, so that they meet the quality requirements.*

Keywords: VMoC120 steel, ionic nitriding, tribological properties

1. Introduction

The final mechanical properties of the cold working devices are the result of the technological interdependent factors, which interfere on the technological flow: processing, casting, forging, preliminary heat treatment, cold treatment, secondary heat treatment, rectifing and surface hardening and tempering by ionic nitriding process applications.

The studied steel has the next chemical composition:

C	Mn	Si	Cr	Mo	V	S	P
1,63	0,42	0,30	11,5	0,51	0,29	0,014	0,01

The hardening is made at 1020-1080°C and tempering at the temperature of 500-520°C. After this treatment it is obtained a hardening structure with 59-61 HRC hardness.

2. Experimental part

Samples with Φ = 15mm and h = 8 mm where token for establishing of VMoC120 steel ionic nitriding process parameters. After the secondary heat treatment, samples are subjected to the ionic nitriding process in the experimental equipment of the Central and Research Laboratory of the S.C. MECHEL Targoviste S.A. Fig. 1. The nitriding process parameters: discharge power, gaseous mixture ratio (x = nitrogen/hydrogen) nitring temperature, exposing time were varied between imposed limits by the initial martensitic structure that must no be destroyed and by the final nitrided structure that must be obtained.

The final structure must have high hardness and high tribological properties in combined layer and tenacious diffusion layer.

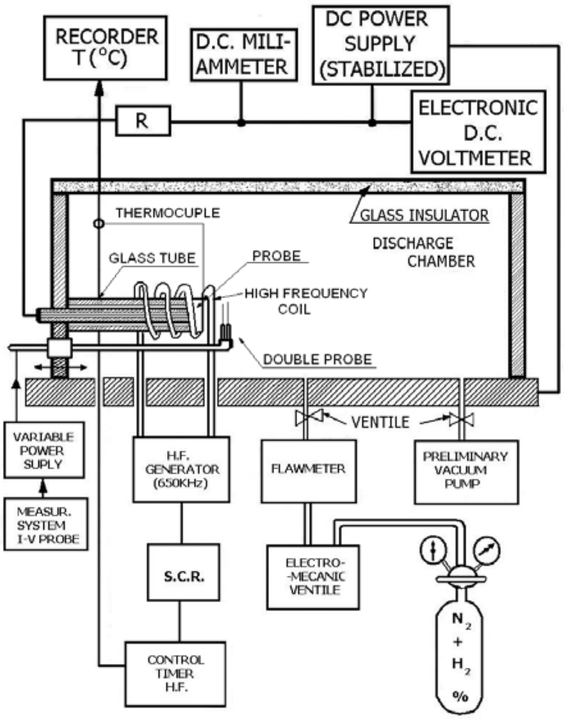

Figure 1. Bloc scheme of the experimental installation.

The micro hardness method for establishing of the nitriding layer thickness is used. The curve HV 0.3 vs. distance by the sample edge was piked up. The *d* value (from the micro hardness profile) at which the layer hardness is:

$$H_V = \frac{H_{VM} - H_{VB}}{2{,}72} + H_{VB}$$

is considered to be the layer thickness. Where: H_{VM} is the maximum hardness of the layer and H_{VB} the basis material hardness (core).

The way in wich the combined layer mean hardness varies with nitriding temperature was analysed within the framework of the experiments made for the establishing steels (with 12% Cr) ionic nitriding technological parameters. The curves $\Delta H_V = f(T)$ are shown in Fig. 2.

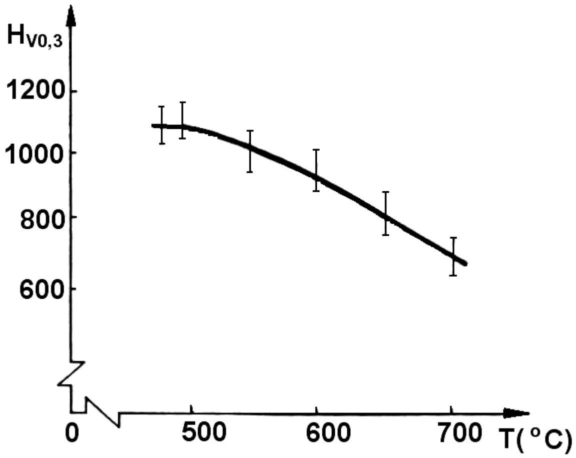

Figure 2. Dependence $\Delta H_V = f(T)$

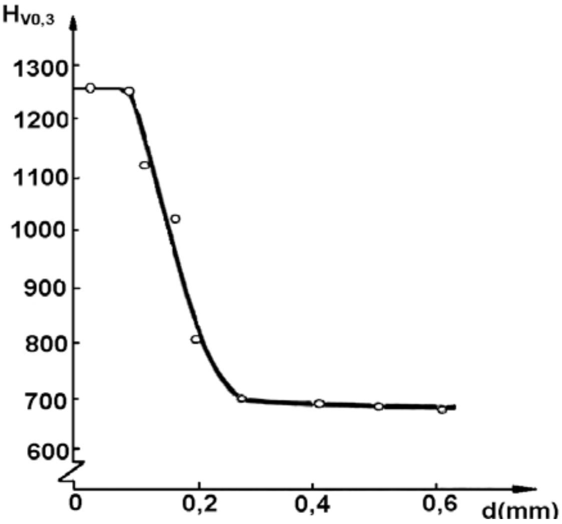

Figure 3. Variation of hardness vs. distance

The micro hardness curve (the profile) vs. distance by the sample edge is presented in Fig. 3. The nitrided layer thickness variation (obtained by the above mentioned method) vs. exposing time for various temperature values is presented in Fig. 4.

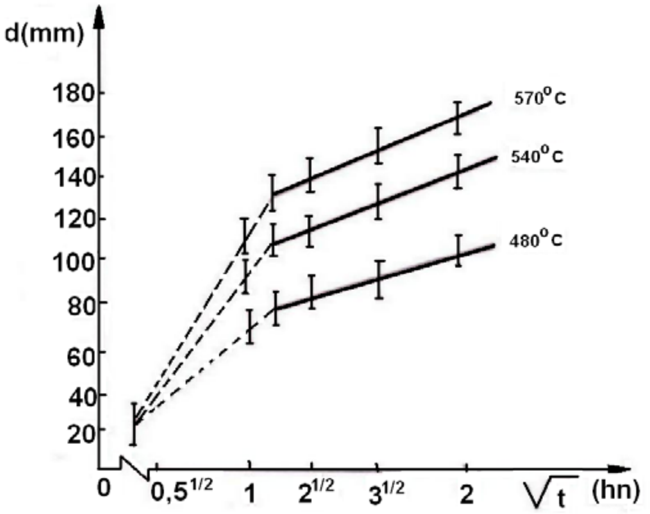

Figure 4. The nitrided layer thickness variation vs. exposing time for various temperature values.

The formation's kinetic of layers at the nitriding of this kind of steel was pursued on samples at the following parameters: I = 12 mA, U = 1400 V, N_2/H_2 = 1/1, $T = 500^{o}C$ and exposing times t = 1h, 1.5h, 2h, 2.5h, 3h. The qualitative and quantitative structural analyse was made by X-ray diffraction. The unit normalization and ASTM card index comparison where used for qualitative analyse. The integral intensity calculation method was used for quantitative structural analyse. Only samples with the same quantity of co-existing phases where take in account and only the representative peacks for the formed nitrided phases: (200) for γ'' structure and (100) for ε structure were analysed.

3. Results and conclusions

The next conclusions can be drawn from the experiments:

- the tempering must be done at a temperature above $t = 500\ ^{o}C$ to assure for the ionic nitriding treatment (that must be done at temperatures under the tempering one) enough temperature.
- the ionic nitriding made on austenitic structure of VMoC120 steel leads to the obtaining of a combined layer realized by γ'' and ε phases with a maximum hardness of $H_{V0,3}$=1250.
- the nitriding layer thickness for various temperatures varies with the exposing time after a $\approx \sqrt{t}$ law (for exposing times among 1-3h)
- the mean hardness of the obtained combined layer is lessening with the increase of the working temperature: from $H_{V0,3}$=1200 at $T = 500^{o}C$ to $H_{V0,3}$= 750 at $700^{o}C$. So, the indicated temperature to obtain a hard combined layer is $T = 500^{o}C$.

The next conclusions are resulted from the diffractograms analyses:

- the configuration of the obtained layers at the ionic nitriding carried out on VMoC120 steel in hardened-tempered state is complex. The superficial layer contains $(Fe, Cr, Mo, V)_4N$ and $(Fe, Cr, Mo, V)_{2,3}N$ nitrides that together with the diffusion layer confers outstanding mechanical properties to the metal [1].

With the increasing of the exposing time (from t = 1h to t = 3h) the ε nitriding quantity formed initially in the superficial layer decrease and the γ'' nitriding quantity increase enough.

So, at an exposing of 2-3h it will be obtained a combined layer formed by γ'' nitride and a smaller quantity (percentage) of ε nitride. The ε nitride has a low hardness but shows superior tribological properties and rust-resisting properties [2, 3].

From these experimental results we can say that the ionic nitriding of VMoC120 steel must be done in the next technological conditions: temoerature T = 480-500°C, exposing time t = 2 ½-3h, gaseous mixture $N_2/H_2 = 1/1$ and pressure p = 3 torr.

Referrence

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