METHOD FOR LOCAL PROTECTION IN PLASMA NITRIDING OF PARTS THAT PRESENT NON-FUNCTIONAL SURFACES

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Abstract: The parts which will be subjected to plasma nitriding and which present non-functional surfaces (surfaces resulted from casting, areas with macro-irregularities, surfaces which contain slag, impurities etc.), can be coated on these surfaces with special protective paints, so that the stages of gas removal-preheating and heating are carried out faster, avoiding powerful electric discharges.

Key words: plasma nitriding, protection paints

1. INTRODUCTION

The metallic parts which will be subjected to plasma nitriding and which present non-functional surfaces, i.e surfaces resulted from casting, areas with macro-irregularities, surfaces which contain slag, impurities etc., can be coated on these surfaces with special protective paints which determine the stages of gas removal-preheating I_1 and heating I_2 (the first two stages of the plasma nitriding process) to be carried out in a much shorter period of time, avoiding powerful discharges in electric arcs [1].

The researches regarding the elaboration of modern, more efficient technologies for the local protection of metallic parts against plasma nitriding with isolating layers have led to creating two original variants of special paints, made of lamellar copper powder in combination with magnesium oxide and polystyrene dissolved in carbon tetrachloride (the symbols used for the paints are V-1 and V-2, when no polystyrene is used)[1, 2, 3].

The experimental tests have proven that the surfaces of the isolating layers of the special paints have a behaviour similar to that of non-coated metallic surfaces. The luminescent discharge ignited a few seconds after starting the process, simultaneously for the protected and unprotected surfaces. The discharges in electric arcs and the scintillations appeared only sporadically, being noted on both types of surfaces only in a small number.

Therefore, the idea appeared to use the elaborated isolating paints not only for preventing the hardening of certain surfaces during plasma nitriding, but also for the coating of surfaces which have no functional role, from which the gas removal would take a long time. These non-functional (non-processed) surfaces are the cause for a very large number of transitions of the luminescent discharges into electric arcs [4].

2. EXPERIMENTAL DETERMINATIONS

In order to evaluate the paints' influence as precisely as possible, in the following the results of three experimental determinations: EXP.1, EXP.2, EXP.3 are presented, which consisted in the unfolding of plasma nitriding processes ($T = 550°C$, $t = 12$ h, $p = 2.5$ torr, process atmosphere 25% N_2 / 75% H_2), applied differently for three types of parts. The samples were discs made of steel 39MoAlCr15, of dimensions Ø60 x 10 mm, hardened to 28...30 HRC, which were prepared for the plasma nitriding in an INI-30 installation (table 1).

The technology for the local protection of metallic parts with non-functional surfaces during plasma nitriding by using paints, imposes a higher efficiency in the functioning of the installation, the energy consumption during the gas removal and heating stages of the process being diminished. This can be achieved through the maintaining of a high degree of cleanness of the installation's walls, of the device used and of the protection systems in use.

The protective layers constitute a new state of the surfaces subjected to plasma nitriding, they determining the decrease of the energy consumption E_{I1} and E_{I2} during the stages of gas removal-preheating I_1 and heating I_2 of the process [1, 5].

Table 1. *Experiments carried out*

Exp. No.	Sample No.	The state of sample's surface
EXP.1	$P_{m\,1}$	Unprotected (metallic glitter Ra=0,025 mm)
EXP.2	$P_{ţ\,2}$	Unprotected (surface with oxidation, slag and macroirregularities)
EXP.3	$P_{p\,3}$	Protected - 0,45 mm (two layers of paint) (initial surface with oxides, slag, macroirregularities)

The stages I_1 and I_2 of a plasma nitriding cycle being responsible for 15-20% of the total energy consumption of the process, the adopted protection variants can reduce the effective durations from several hours to tens of minutes, depending on the parts complexity and on the lot size [6].

During the bombardment of the cathode, the kinetic energy of the ions is consumed for the heating of the surface and for the freeing of electrons and of iron atoms. These particles can form persistent deposits on the vessel's inner surfaces, leading to their "blackening" and to an increase of the emissivity coefficient from e = 0.4 to e = 0.7...0.8, simultaneously with a reduction of the reflection coefficient (fig. 1, a and b). The heat losses through radiation reach values three times higher than for clean surfaces. Because in such cases, the power absorbed by the installation increases by up to 50%, the inner surfaces need to be cleaned periodically (after 8...15 cycles), so that they regain their maximal reflection capability [7].

Also, the usage of screening systems for the protection against heat radiation is important. The protective device consists in 2 or 3 concentrical metallic heat screens, of low thickness, closed and with polished interior surfaces, introduced between the parts and the vessel's wall. Another simple solution is to adjust the active space to the dimensions of the lot of nitrided parts, by using 2-3 movable metallic discs, which render inactive the part of the vessel which goes beyond the protected parts. In both situations, the first screen or disc will be blackened after the first nitriding, the other ones maintaining a high reflection coefficient.

3. CONCLUSIONS

The experiments have led to following general conclusions:

- for the first stage, the durations for the sample P_{m1} and P_{p3} are similar (5 minutes and 6 minutes, respectively, at 220ºC);

- for the sample P_{m1}, the second stage is carried out without difficulties, the process temperature being reached relatively soon (14 min.);

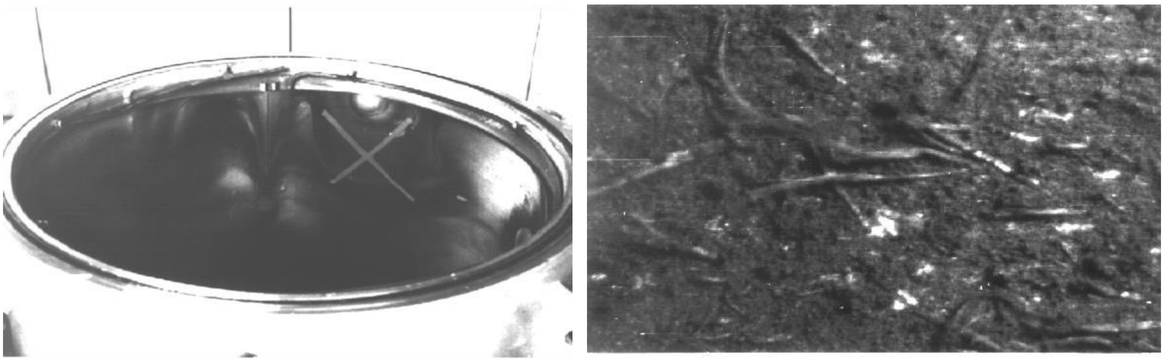

Fig. 1 *Deposits formed on the surface of the recipient's walls during nitriding*

- for the sample P_{t2}, the stage gas removal-preheating occurs with a delay of 10 min. and the nitriding temperature is reached after 36 min.
- for the sample P_{p3}, during the second stage the luminescent discharge remains stable from the start; from time to time, at the part's surface appear electric arcs, causing an interruption of the luminescent discharge; the protective layer constitutes a heat barrier, so that the time for reaching a stable regime is of 24 min.

The analysis of the protective layers' influence on the duration of the plasma nitriding process has shown that this parameter depends on the temperature, but also on the thickness of the layers. Thus, there is a significant reduction of the durations after which stable regimes are reached, which is inversely proportional to the protective layers thickness [8].

The cooling durations for the protected samples increase with the thickness of the protective layers. There is a significant difference in temperatures between the protected and unprotected metallic parts, during the entire process, difference which increases with the layer thickness [9].

The energy consumption can be reduced by: periodical cleaning of the inner surfaces of the installation; carrying out the nitriding at the highest possible loading degree; introducing more devices for the screening against heat radiation; adjusting the loading device so that its surface is minimal; adjusting active space of the vessel to the size of the nitrided lot.

The applying of the mentioned measures can lead to a reduction with 25...55% of the energy consumption at plasma nitriding, which for a large installation can represent a reduction of 150...250 MWh, and for a small installation a reduction of 100...200 MWh.

The reduction of transitions from luminescent dis-charges into electric arcs during the cleaning and heating stages, when using the special protection paints, presents following advantages: the mechanical processing of non-functional surfaces after nitriding is eliminated; the forced-extinction block of the installation is protected, which increases the life time of the installation and avoids the contamination of the work atmosphere, so that the quality of the nitrided layer on unprotected areas remains high [14].

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