

A MODERN METHOD FOR THE LOCAL PROTECTION OF PARTS DURING PLASMA NITRIDING

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Abstract: This paper presents the researches carried out for the obtaining of paints for protection during plasma nitriding. Over 120 different compositions have been tested, of which 2 were eventually considered to offer an adequate protection under the severe technical-economic conditions imposed (easy removal after nitriding, no interference with the chemical composition and structure of the superficial layer of the steel etc.). The paints are applied with a brush and the minimal drying time until the introduction of the parts in the heating chamber, is 2-3 minutes. After the plasma nitriding, the paint is removed simply by wiping the metal surface with a cotton cloth or another textile material. Safety measures during the use of the paints do not differ essentially from those currently used in the degreasing of parts for plasma nitriding.

Key words: plasma nitriding, protection paints

1. Introduction

When atoms of a foreign element are added to a solid state system, they cause an increase in the free energy. Since every system tends to reach its equilibrium state with the minimum energy, a transformation can occur and a new phase can be formed. One of the most fundamental processes by which a system attempts to reach a stable arrangement of its atoms is diffusion. These two phenomena, phase formation and diffusion, are of significant importance for the formation and growth of the nitride layer during ion nitriding.

Traditional Methods of Nitriding The traditional methods of nitriding are based on deriving a source of nitrogen from a gas or compound. The two common sources of nitrogen are ammonia for gas nitriding, and cyanide to cyanate decomposition for salt bath nitriding. The gaseous method of nitriding is based on the simple decomposition of ammonia to its nascent forms.

The elaboration of newer and more efficient technologies for the local protection of metallic parts against plasma nitriding laid the foundation for the production of two types of special

protective paints based on sub-microscopical copper lamellas in combination with magnesium oxide. In the case of the first paint, (V-1), the aforementioned mixture is dispersed in a polystyrenic varnish (polystyrene dissolved in carbon tetrachloride), and as concerns the second paint, (V-2), the mixture is dissipated only in carbon tetrachloride, [1].

The experimental researches demonstrated that the behaviour of the special protective coats of paints was similar to that of the unprotected metallic surfaces. The glow discharge started a few seconds after the installation had been started, for the uninsulated and insulated surfaces concomitantly, the ionic bombardment being rapidly released (a few discharges in electric arc and minor scintillation occurred sporadically on both types of surfaces).

The special paints have been used not only against nitrogen diffusion (i.e., hardening) during the ionic nitriding of certain surfaces of the parts, but also for coating certain unprocessed (nonfunctional) areas which require a long-term degasification.

These areas could be represented by: surfaces resulted from casting with

hardened slag, residues, black oxide, areas with macroirregularities, oxidised areas, with impurities, [1, 2].

This paper presents the extensive experimental researches carried out for the obtaining of special paints for the local protection of the surfaces of metallic parts subjected to plasma nitriding. The protection was meant to prevent the superficial hardening of certain areas of the parts. As part of the researches, over 120 compositions based on organic or inorganic binders, refractory oxides, oxides, metallic powders etc. (fig.1). Some of these have been excluded during the tests, due to the difficulties related to the removal after the plasma nitriding, to their chemical or physical instability or

due to their inefficiency against superficial hardening, [3, 4].

In the end, only two variants of protective paints have been retained (table 1), which have offered an efficient protection under the set of severe technical-economic conditions imposed in advance (easy removal after the process, non-affecting of the chemical composition and of the structure of the metallic surface, quick drying, etc.). The mixtures are based on sub-microscopic copper plates (lamellae) dispersed in polystyrene lacquer (polystyrene diluted in carbon tetrachloride) or dispersed only in the carbon tetrachloride, mixed with magnesium oxide [5, 6].

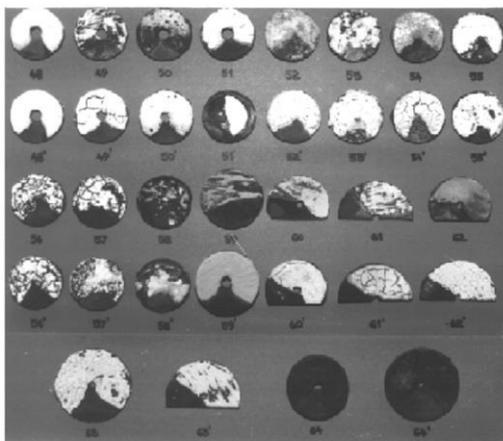


Fig. 1 Aspect of some samples after nitriding

Table 1. Characteristics of the paints used for the local protection at plasma nitriding

Characteristic	Paints V - 1 / V – 2
The duration of drying per layer (number of necessary layers)	2...3 min. (1...2 layers)
Compatibility of the components	very good
Spreading capability	Good
Capability of avoiding outflows and thinning at the edges	very good
Coating ability	very good
Capability of adhering to the base metal	very good
Gas emission capability	None
Friction resistance after drying	very low
Friction resistance after plasma nitriding (adherence to the layer below it)	very low

Protection offered to the metallic surface (structure, chemical composition, hardness)	very good (regardless of the duration of its subjection to the nitriding)
Quality of the copper powder (dimensions / ratio on the coated surface unit)	Microscopic lamellae 5...30 μm 15...80 %
Complexity of the protected parts' geometry	very high
Removal capability after the process	very easy
Aspect	viscous product, reddish-carmine colour
Smell	specific for chlorinated organic solvents
Volumic mass	2,5...0,5 g/cm
Contents in non-volatile substances	62...74 %

2. Experimental Results

The choice of *copper* as main metallic component of the protective paints is justified by a series of characteristics which it presents, in the context of the physical-chemical phenomena (at the cathode and in the gas volume) taking place during plasma nitriding [8].

The bombardment of the cathode by positive ions determines on the one hand a process of emission of secondary ions, but also the emission of particles from the composition of the cathode (atoms, ions etc.), taking place also a *superficial activation* of the surfaces which are subjected to the process. In this manner, the *physical cathodic pulverisation* occurring on the protected areas (at the copper surface) will free, through the impulse transfer from the incident particles, atoms from the superficial layer of the protective layer, and not atoms from the base metal. In consequence, the copper represents in this way a *physical blockade*, isolating the metal surface which must be protected from the ionic bombardment.

Regarding the *chemical cathodic pulverisation*, the presence of copper in the protective layer eliminates the chemical component of the cathodic pulverisation, because, at the temperature at which plasma nitriding occurs (450...600°C), there is no possibility for the formation of copper nitride (Cu_3N), since it decomposes at the temperature of

~300°C (the protective copper-based layers will "refuse" the nitrogen during the plasma nitriding process).

The copper can be obtained as lamellar powders or as microscopic plates of colloidal or quasi-colloidal size and thus allows the realisation of suspensions with the polystyrene lacquer and with the very small-sized magnesium oxide, so that the elaborated mixture can be applied uniformly and compactly on the metallic surfaces that need protection.

The addition of the *magnesium oxide* improves, due to its good resistance to high temperatures and of the powder state, the resistance of the copper plates during plasma nitriding. The aggregate-type composition which is formed, withstands very well and for a long period the ionic bombardment, the cathodic pulverisation and the regime temperature characterising the procedure. The magnesium oxide prevents the solidifying of the entire protective layer, so that the removal of the paint at the end of the process is done very easily, the magnesium oxide and the copper powder that did not melt facilitating its removal.

The experiments were carried out on a plasma nitriding *Klöckner-Ionon S 750 x 4500*, the parameters being: $T = 550^\circ\text{C}$, $t = 22 \text{ h}$, $p = 2.5 \text{ torr}$, process atmosphere 25% N_2 and 75% H_2 . The samples used were discs (made of a nitriding steel - 39MoAlCr15) with the dimensions $\varnothing 60 \times 10 \text{ mm}$, hardened at 28...30 HRC, fine grinded to $Ra = 0.025 \text{ mm}$ and degreased.

The samples were subjected to analyses of the chemical composition, to HV 10 hardness determinations in the superficial layer, HV 0,1 micro-hardness determinations in the cross-section of the superficial layer, mechanical processing (before and after the plasma nitriding), comparatively on surfaces unprotected and protected by paints.

The determinations carried out have proved that the mixtures ensure the avoiding of superficial hardening of the protected areas and the maintaining of the physical-mechanical characteristics of the protected surfaces at the levels from before the nitriding (allowing the carrying out of mechanical processing afterwards), as well as the avoiding of the modifying of the working environment's composition from the process container during the ionic nitriding.

The metallic surfaces which will be protected do not require a special preparation, they need only to be well cleaned, to metallic polish and then degreased.

The technology of applying the paints consists in brushing until the complete covering of the metallic surfaces with a relatively even layer, of thickness 0.2...0.3 mm. After nitriding, the removal of the protective paints is done by the simple wiping of the protected surface with cotton or another textile material.

In the case of surfaces with sharp edges (including threads), those edges need to be coated carefully, being recommended to apply a supplementary layer about 10 minutes after the base layer has been applied and dried.

All these remarks constitute arguments in favour of recommending the two types of protective paints for their usage at the local protection against plasma nitriding.

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