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SOME ASPECTS OF ION NITRIDING TECHNOLOGY AT NITRION 10 INSTALLATIONS

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Abstract: *The paper proposes an analysis of the technology performed in NITRION 10 type ion nitriding plants. Based on the experience of 30 years of operation of these plants we are able to offer some solutions aiming at improving the ion nitriding technology. These solutions refer to ion nitriding of parts with thin edges, ion nitriding of channels, the maximum charge which can be nitrided in these systems, charging devices and mechanization of charge. We believe that these installations which have proven good reliability can be used successfully for a long time if appropriate technological solutions are applied.*

Key words: *ion nitriding, NITRION 10 installation, thin edges, channels, charging mechanization.*

1. Introduction

At present ion nitriding is a basic technology in surface engineering. Ion nitriding installation type NITRION 10 with which many heat treatment workshops are gifted, are well type, with cold walls, with relatively small installed power (15 or 20 KW) and a relatively large flask (useful area 400 x 1700 mm) [1-4], [12].

Working atmosphere in ion nitriding installation type NITRION 10 consists of dissociated ammonia in the proportion of nitrogen and hydrogen which remains rigorously constant but may also use gas mixtures prepared without the need for constructive changes.

Using gas mixtures allows to optimize energy consumption and to obtain all possible configurations offered diagram Fe-N-C [5], [11]. The NITRION 10 installation facilities are successfully operated even nowadays. This emphasizes the high reliability, high flexibility, low consumption and easy maintenance of these facilities.

The disadvantages of this type of installation refers to the weakening of ion nitriding thin edges of parts, non-uniform nitruration or double cathode phenomenon at nitriding of cavities, channels or threaded or unthreaded holes, too little power relative to available premises, difficulties due to suspension parts and settlement mechanism lifting the lid retorts [6-10].

This paper proposes a pertinent analysis of the above mentioned drawbacks and present solutions adopted in UTCN or which can be made to improve the operation of these facilities.

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2. Analysis of Deficiencies of Ion Nitriding Installation Type NITRION 10

Ion nitriding installations type NITRION 10 show a series of ion nitriding technology specific deficiencies such as:

- high fragility of the pieces with sharp edges in particular those of high alloy steels where the passage to the core area is very steep;
- the deterioration of parts by increasing the surface roughness as a result of an intense sputtering and seating surfaces of the devices are the bumps and nicks that occur in the sputtering process (cleaning with micro-arches);
- appearance of double cathode effect in parts with cavities or blind holes or pierced, causing local overheating of parts;
- nitrided layer non-uniformity on the inner surfaces of long and shaped pieces.

A second category of deficiencies are specific to ion nitriding installation type NITRION 10:

- too little installed power (10-15 kW) reported to the premises available, which results in a low area utilization;
- the time of a relative ion nitriding cycle due to suction and sputtering operations, which negatively affects productivity;
- difficult charging of parts with low area and relatively high seating that can reverse or even fall off the device, as following the suspension system of the cap flasks.

3. Solutions to Improve the NITRION 10 Installations

Nitrided layer thickness, DNI (Figure 1) for parts measured angular bisector angle α depends of temperature and time through thickness δ.

Relationship of calculation from the measurements is as follows:

$$DNI = 1.5 \cdot \frac{\delta}{\sin\frac{\alpha}{2}}, \quad (1)$$

where: *DNI* - nitrided layer thickness on the angle bisector of the edge, mm; δ - thickness of the nitrided layer, measured on the side of the angle α, mm; α - angle edge, $15^0 \leq \alpha \leq 90^0$, for $\alpha > 90^0$ coefficient value decreases gradually from 1.5 to 1 after: 1.54 – 0.003 α.

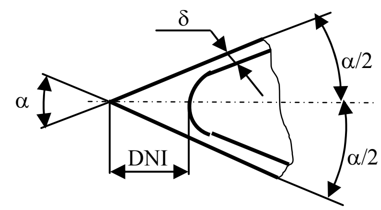

Fig. 1. *Nitrided layer thickness, DNI on the bisector angle α*

The fragility edges increase as much as the report DNI/δ proportionally increases. High fragility of the pieces with sharp edges ($\alpha \leq 90^0$) can be reduced by nitridings with short duration: 0.2 to 1 hour. Thickness is obtained as *DNI* = 0.1 – 0.2 mm corresponding to a δ = 0.01 – 0.1 mm.

Uniformity of the ion nitrided layer depends on the temperature uniformity of charge. Temperature of pieces depends mainly of geometric shapes, relative positions, the charge device and work pressure. Geometric shape of the piece is a given characteristic so that the elements on which one can act in a uniform temperature are: position (layout) parts, construction of charge device and work pressure. The devices are conceived to allow a symmetrical distribution of parts in the axis of symmetry and nitration container also a similar position to the vessel wall (anode) and to neighboring parts. Working pressure is the third factor which may influence temperature uniformity, respective that of the nitrided layer. Pressure is limited to a specific plant part NİTRİON 10 (up to 5.5 torr) and on the other hand, a phenomenon known as double cathode effect. An inadequate pressure can lead to non-uniformity temperature, respective to appearance of the cathode double phenomenon which can cause local heating with hundreds of degrees above the temperature regime. The relation between the diameter (open) cavity, the thickness of cathode fall and working pressure that favors the double cathode effect is:

$$D \le (2 \div 3)\, d_n \cong \frac{8.4}{p} \dots \frac{12.6}{p} \tag{2}$$

where: D is the diameter (openening) of cavity; d_n - the thickness cathode fall (the distance between the cathode and negative light luminescence abnormal discharge); p - pressure.

To avoid double cathode effect to blind holes following relations must be considered:

$$6D \le h \le 12D, \tag{3}$$

or:

$$12D \le h \le 22D. \tag{4}$$

For holes with diameter D = 3...10 mm we apply relationship 3 and for holes with diameters D > 10 mm (h is the depth of the hole) relationship 4. Depth that can be nitrided for penetrate holes is the double of blind holes. For the nitride holes and cavity with $D \ge 3$ mm and $H/D \le 3$, the pressure is chosen according to the diagram in Figure 2a. It may be noted that in this case nitrided layer is uniform in both the cavity and the product surface (Figure 2b).

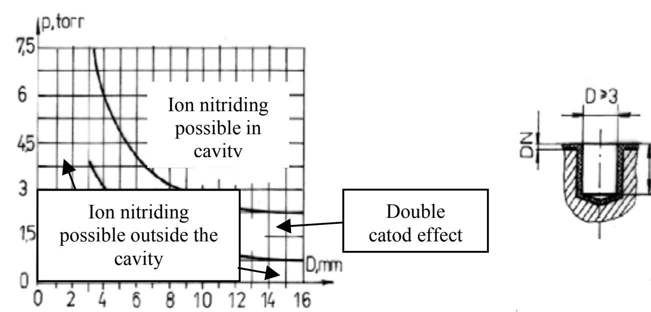

Fig. 2. *Diagram for the choice of working pressure of the ionic nitriding of holes with D ≥ 3 mm and H/D ≤ 3* [8]

For holes, respective cavities plugged with $H = 12D - 15$ (Figure 3a) and holes crossing with $D \ge 3$ mm and $L = 2H$ (Figure 3b), the choice of the pressure diagram is represented in Figure 4.

Working pressure can also be chosen from an experimental relationship which links minimum nitriding pressure and the hole diameter:

$$P_{\min} \ge 13 - \frac{D}{2}, \tag{5}$$

where: $P_{\min}$ is the minimum working pressure required to avoid double cathode effect in torr; D - diameter hole (cavity) in mm.

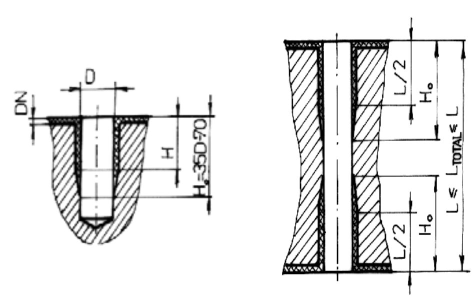

Fig. 3. *Schematic representation of the holes with D ≥ 3 mm and how to change the depth of the nitrided layer thickness hole* [8]

Double cathode effect can be avoided in many cases by placing the piece in a horizontal position if possible and if the wall thickness is large enough not to cause dimensional changes. This solution allows the creation of a layer of uniform thickness for nitriding of small apertures and long and shaped inner surfaces. Nitrided layer uniformity is very important for interior surfaces, especially for those profiles (grooves, threads etc.) in the case of parts made of stainless steel or high alloy where the nitrided layer has maximum depth of 0.20-0.25 mm.

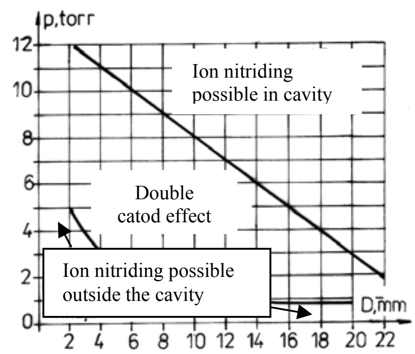

Fig. 4. *Diagrams for the choice of working pressure with inner holes nitration with $D \geq 3$ mm* [8]

In the case of a piece of threaded bushing type, vertical positioning on the charge area resulted in an non-uniform ion nitrided layer (Figure 5).

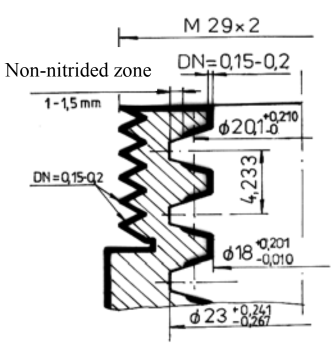

Fig. 5. *Nitrided layer nonuniformity*

The horizontal positioning of the piece and use of a working pressure of 2 torr has managed to achieve a uniform layer and the inner trapezoidal thread profile (Figure 6).

Increasing of coarse roughness observed on the top edge intense sputtering requires in the case of ion nitriding of angular parts as small as possible of cathodic sputtering.

Replacing the original transformer of 15 KW to a 20 KW transformer allowed the increase of the burden surface to 1.05 m^2 from a batch of 0.5 to 0.7 m^2. The increase of the installed led to increased reliability of the power plant through the use to maintain temperature of large batches of 550 V step instead of 750 V step.

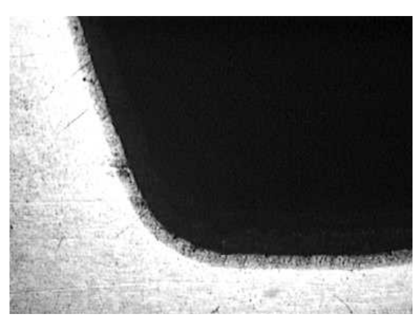

Fig. 6. *Microstructure of nitrided layer of the inner thread threaded bush*

Using a higher vacuum pump type PVP 60 instead of the initial pump PVP 25 resulted in shortening of the suction operation and a slight increase in the consumption of ammonia.

Reducing the time of sputtering operation can be achieved by further finishing of rough surfaces of the parts and use of clean charge devices. Making a perfect contact between the surface as part settlement and pan support area requires periodic cleaning of surfaces by sanding and grinding haul. It is therefore preferable to make possible the suspension of parts with fasteners which provide a more perfect contact.

One of the solutions to improve the lifting system - lower of the lid retorts is to replace the manual system with cable with a hydraulic or pneumatic action and guiding the three columns cover. This solution can be applied to existing equipment at minimal cost.

4. Conclusions

Ion nitriding technology analysis carried out in NITRION 10 type plants revealed major shortcomings faced by users of these installations. Based on over 30 years of experience of operation of these facilities we have tried to offer some solutions to improve the technology of ion nitriding for these facilities.

These solutions resulting from several experimental research and productive activities focused on:

- ion nitriding of parts with sharp edges, channels, holes and internal cavities;
- the uniformity of nitrided layers;
- the roughness of angular parts;
- avoiding double cathode effect;
- the maximum charge which can be nitrided in those facilities;
- devices and mechanization of charging.

We believe that these machines that have proven good reliability can be used successfully for a long time if we take into account the solutions proposed in this paper.

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