NITRICATNOX

ONE TREATMENT MULTIPLE SOLUTIONS

WHY NITRICAT-NOX?

NITRICAT-NOX®is a combination of an innovative gas nitriding process NITRICAT® and an advanced post-oxidation process in a controlled gas atmosphere. The result is a surface treatment suitable for a great variety of steels, which gives excellent mechanical properties and corrosion resistance. An accurate control of each phase of the treatment allows managing specific customer needs, acting directly on the metallurgical properties of the functional layer in relation to the characteristics of the component or material.

The NITRICAT-NOX® treatment is particularly suitable for applications in which corrosion resistance is required in particular atmospheric conditions, industrial or marine environments together with an increase of superficial mechanical properties such as hardness, fatigue resistance and wear.

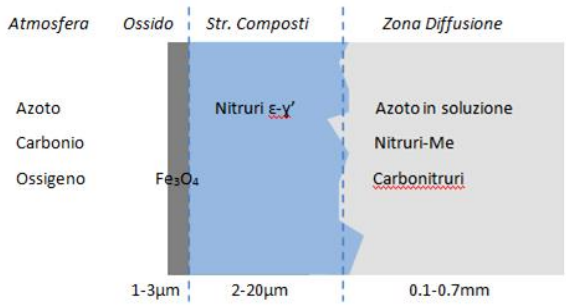
CONTROLLED GAS ATMOSPHERE

The full electronic control of the atmosphere during nitriding and oxidation stage is the innovative feature of NITRICAT-NOX® process. The treatment is completely in gas atmosphere to allow accurate management of flows and gaseous mixtures thanks to the control of reaction kinetics with the advantage compared to other treatments. The benefits of this technological choice reflect on quality, flexibility and repeatability of the treatment.

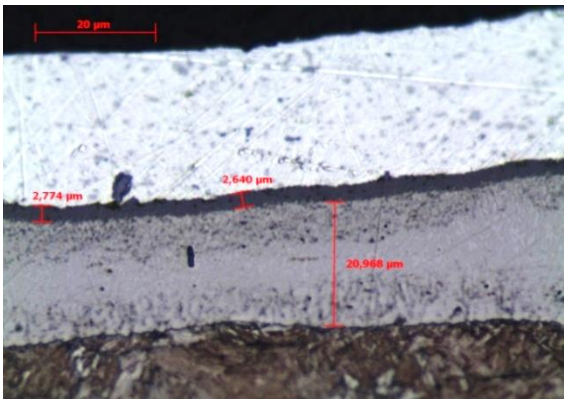
The chemical reaction at the base of oxide layer growth is the oxidation of iron inside the compound layer:

$$\frac{3}{4}Fe + \frac{1}{2}O_2 \rightarrow \frac{1}{4}Fe_3O_4$$

In order to obtain layers of high quality and able to provide excellent resistance to corrosion it is important to control the process from the early stages accurately. The electronic control of the process is built on a mathematical model and allows automatic process ensuring maximum control and repeatability of the results. During the NITRICAT-NOX® process the nitriding layer is the substratum for the subsequent oxidation process. The structure of the treatment consists of three layers: the diffusion layer, the layer of compound and the oxide layer.



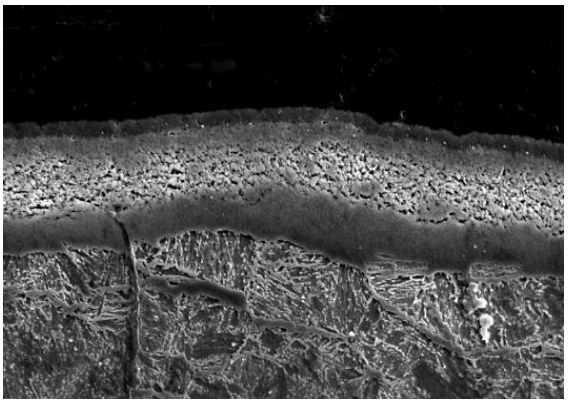
The diffusion layer ensures increase of mechanical properties of hardness and resistance to fatigue by acting as a supporting substratum for subsequent layers. It forms during the first stage of the process, which consists of the nitrogen diffusion from the atmosphere gas inside the material. Its thickness is tailored on the customer's request, between 0.10mm and 0.70mm. This layer is one of the main features of the NITRICAT-NOX® treatment, which is missing in all electroplating treatments, which suffer of spalling and case crushing failures.



Optical micrography – Etchant Nital 3% - Magnification 1000X - NITRICAT-NOX® layer on 20MnCr5 steel

The second layer is the compounds layer constituted of Iron nitrides, it determines the resistance to wear and abrasion, as well as contributes to corrosion resistance. Thanks to optimization of this layer obtained by the NITRICAT-NOX® process, we can achieve required characteristics in function of the material used or the specific application of the component.

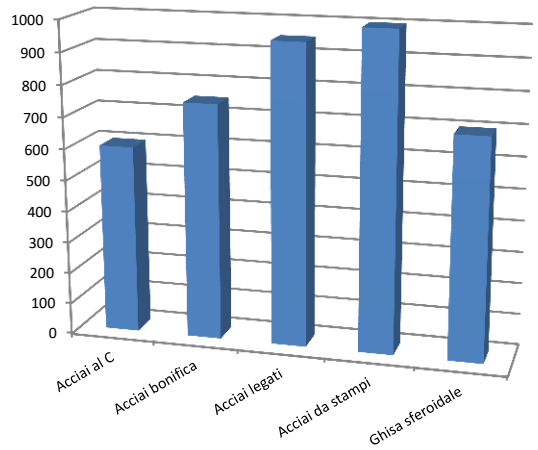
The last layer is essential for corrosion resistance. It consists of a uniform layer of Magnetite (Fe_3O_4), a particularly stable iron oxide. Laboratory analysis has shown that the magnetite formed during the NITRICAT-NOX® process has a potential of electrochemical pitting even higher than that of austenitic stainless steels.



Electron Scanning Microscope (SEM) image of the NITRITICAT-NOX layer

SURFACE HARDNESS

Surface hardness obtained after treatment is a function of the characteristics of the base material (chemical composition, preliminary treatment) and is usually measured in Vickers (HV). It can vary starting from 350HV1 (low alloyed steels) up to 1200 HV1. Thanks to the NITRICAT-NOX® process, it is possible to enhance the characteristics of the base material archiving optimized hardness for the characteristics required, while maintaining high geometrical stability and the best metallurgical quality.



Vickers surface hardness obtained after NITRICAT-NOX® on different steels

Achievement of high surface hardness allows using even materials with modest mechanical properties (eg. Carbon steel or cast iron), for example in applications where wear resistance is a key feature required the NITRICAT-NOX® layer has a self-lubricating and anti-seizure action.

HARDNESS GRADIENT AND DIFFUSION ZONE

Another advantage of the NITRICAT-NOX® treatment is the presence of a hardening gradient below the surface, which brings many advantages to mechanical application.

In applications requiring surface hardness and at the same time contact fatigue, the presence of a strong substratum below the hardened surface heps to avoid the risk of layer collapse. The characteristics of this gradient, known as a diffusion layer, are a function of the material and are controlled during the NITRICAT-NOX® process in order to develop the best condition for each application.

Other hard surface treatments like Chromo plaiting or PVD don't have the possibility to create a hardness gradient in the substratum wich results in many failure problems caused by case crushing under a heavy load usually applied on an application where this treatment is requested.

DEFORMATION? NO THANKS!

The NITRICAT-NOX® treatment is developed in order to minimize the risk of deformations and in respect of the most restrictive dimensional tolerances. This innovation is a key feature introduced by NITRICAT® process with accurate control of metallurgical characteristics and lower treatment temperatures.

The increase in size on all surfaces of the treated component is limited to the thickness of the transformed layer during the process, usually including the range of 0.0005-0.0015 mm on plane surface and 000.1-000.2 mm on diameter.

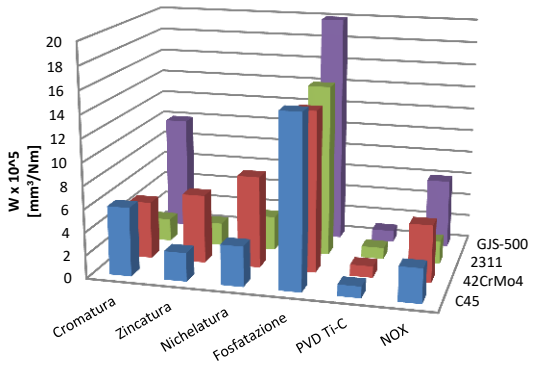
The geometric deviation that exceed these values is due to thermal deformations caused by the thermal relief. To reduce the risk of such deformation, uncontrollable and unpredictable, the NITRICAT® process and the NITRICAT-NOX® process, thanks to the catalytic technology, allow using lower temperatures and treatment time compared to traditional treatments, factors that help to reduce the risk of deformations on critical or complex geometry.

FATIGUE RESISTANCE

Tests carried out on different materials show an increase in the fatigue limits between 60-70%. This is of great interest to all mechanical applications involving cyclic stress like Hertzian stress or pure sliding contact. Most of the mechanical failures start from fatigue and wear phenomena. The hardening layer generated by the NITRICAT-NOX® process produces a state of tension on the finished part's surface pre-stressing particularly suitable to counteract the phenomena of fatigue.

WEAR RESISTANCE

Conventional nitriding treatment is often used for its anti-friction properties and wear resistance. The NITRICAT-NOX® process, thanks to the presence of the oxide layer and its controlled morphology, further these features even more.



Sliding contact wear comparison between NITRICAT-NOX and other treatments on different materials

The oxide presence improves wear coefficient, in particular in the tribo-oxidative systems, while porous morphology helps the phenomena of micro-lubrication during contact. Laboratory tests show that in fact protective oil particles are trapped in the pores of the surface layer carrying a bearing lubricating effect during matching.

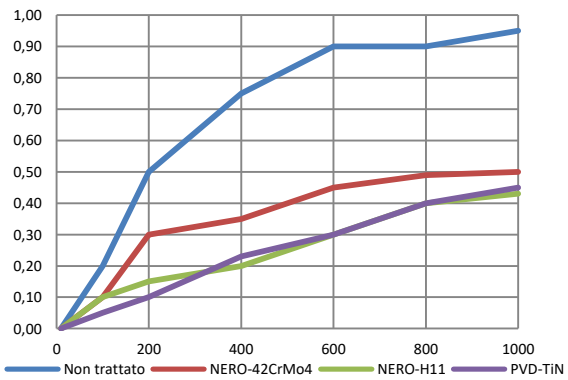
Resistance to tempering, typical of nitrided steels, ensures a constancy of mechanical properties up to temperatures close to those of treatment (about 600°C). Although the oxide layer consists of magnetite it is also extremely resistant to the increase in temperature, in particular due to its high adhesion and excellent toughness conferred by the NITRICAT-NOX® process control.

The NITRICAT-NOX® treatment allows a reduction of at least an order of magnitude compared on the untreated material, or to simple surface protection treatments, such as browning or phosphating. Presence of the oxide layer improves wear resistance with respect to the nitrocarburizing, in particular in the tribo-oxidative wear conditions.

FRICTION COEFFICIENT

The NITRICAT-NOX® treatment has excellent tribological properties, mainly due both to the layer of compounds and the the overlying oxide layer. Friction coefficient shows values around 0:40 to 0:50 in steel-stee pairing (see the table).

Friction is a force that opposes sliding of two bodies one against the other. Friction coefficient is a measure that allows quantifying its absolute value and is strongly related to surface roughness and nature of the surfaces in contact. One of the most frequent causes of failure is precisely due to phenomena of contact surfaces wear. The NITRICAT-NOX® treatment therefore lends itself to applications requiring quality of wear resistance, and in general, wherever influence of friction coefficient is decisive for final performance of the component.



Pin-on-disc friction coefficient comparison: NITRICAT-NERO vs. PVD-TiN

SURFACE ROUGHNES

Surface roughness is a very important value in defining wear behavior of a component. Increase of surface roughness after treatment is related to many factors, such as initial roughness, layer thickness of the compounds, degree of porosity and morphological characteristics of the oxide.

Example of NITRICAT-NOX® applied on pneumatic cylinders whit final roughness 0.2Ra

The NitriCat NOX-treatment enables to control many of these factors, in particular constitution and the oxide morphology, ensuring smaller increase in surface roughness even with high thickness of the layer of compound. The increase of roughness is about +0.1 Ra allowing, in many applications, elimination of the operation of rolling or final lapping. The distinguishing feature of the NITRICAT-NOX® treatment, compared to its competitors, is that the process is performed entirely in the gaseous phase, a feature that allows reducing to the minimum increase of surface roughness.

An accurate control of the atmosphere potential at every stage of the process allows you to have full control of metallurgical and mechanical characteristics related to it, and thus also the final roughness.

HIGH ADHESION TO SUBTRATE

Adhesion plays a fundamental role in the characterisation of a coating; it is important that the entire surface results stable and durable in time.

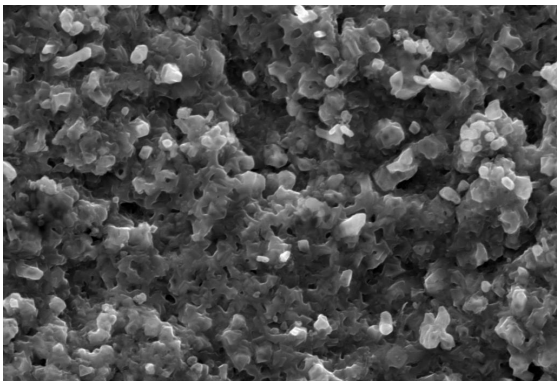
The NITRICAT-NOX® process guarantees ***high adhesion of the functional layer*** (white layer + oxide layer) to the substratum.

Unlike electrolytic process, hot-dip coatings or PVD, where adhesion is produced by mechanical anchoring to the substratum, in the NITRICAT-NOX® process functional layer grows directly from base material as reaction of the surface and the process atmosphere.

This characteristics guarantees an ***optimal adhesion*** and, in contrast to other coatings, is ***very homogeneous*** as thickness and distribution on the entire surface of the workpiece***, regardless of its geometry***.

OIL IMPREGNATION, TO PERFORM EVEN MORE

A characteristics of the magnetite oxide layer generated by the NITRICAT-NOX® treatment is its nano-porosity, which makes it particularly suitable for post-impregnation with special lubricant oil, which further elevates corrosion resistance.

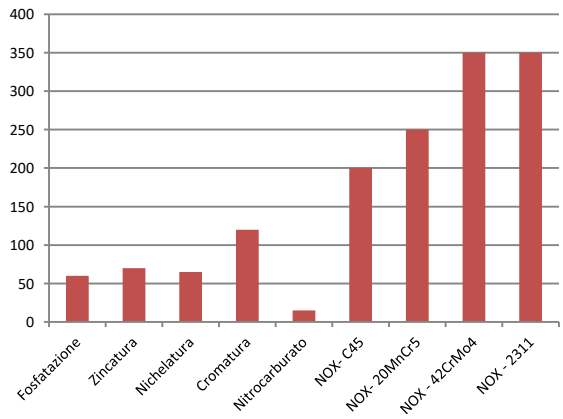


Micro-porosity of oxide layer on SEM electronic microscope

This stage is performed by deposition (spray or immersion) of specific lubricant oil containing corrosion inhibitor agents, penetrating within surface porosity, sealing the oxide layer, providing further barrier to external agents.

This protective film leads to further advantages carrying antifriction lubricant action in operating conditions. One of the main features of the NITRICAT-NOX® treatment is the ability to increase corrosion resistance of the treated materials.

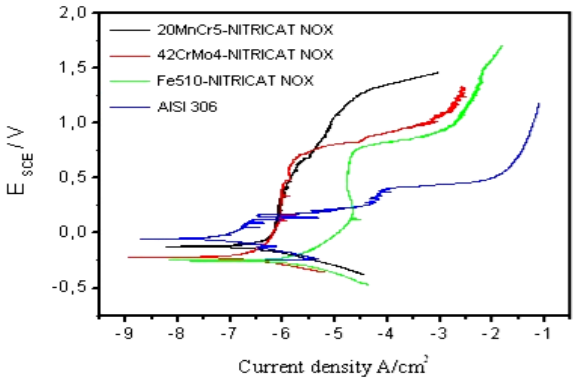
This increase is obtained due to the formation on the surface of oxide layer. The magnetite, which constitutes this oxide, is particularly adapt to resist corrosion in extreme conditions, even with solution containing acids (i.e. Sulfuric acid).



Corrosion test results (hours) of NITRICA-NOX during ASTM B117 test

Tests performed according commonly used standards ISO 9227 or ASTM B117 on different types of materials processed by the NITRICAT-NOX® and compared with the traditional anti-corrosive processes show, in most conditions, superior performance. The tested materials are the most common among construction steels (C45, 20MnCr5, 42CrMo4, 2311) and cast iron (GJS-600). The test consists in the measurement of hours needed to trigger a certain degree of corrosion on the specimen in a controlled nebulized saline solution.

Another way to evaluate corrosion properties is that of potentio-dynamic curves. This test performed on the NITRICAT-NOX® layer shows a very extended passivation field , of order of 800-850 mV and 4 A/cm^2 corrosion current, values comparable to those obtained by austenitic stainless steels like AISI 306 respect to which the NITRICAT-NOX® treatment presents higher passivation, and then higher resistance to corrosion pitting.



Corrosion curves for different steels treated with NITRICAT-NOX against AISI 306

According to these tests components treated with NITRICAT-NOX® present 10-20 times higher corrosion resistance than the "untreated" condition, 5-6 times the burnishing or phosphate treatments, 2-4 times the Ni-Cr plating.

Another advantage, which distinguishes the NITRICAT-NOX® treatment from competitors, is due to homogeneity of the layer and to absence of defects, such as micro cracks, often present in coatings produced by electrodeposition or spraying.

NITRICAT-NOX® performance is verified by certificate and international test standards, we use most advanced investigation methods in order to provide a scientific quality proof for our treatments.

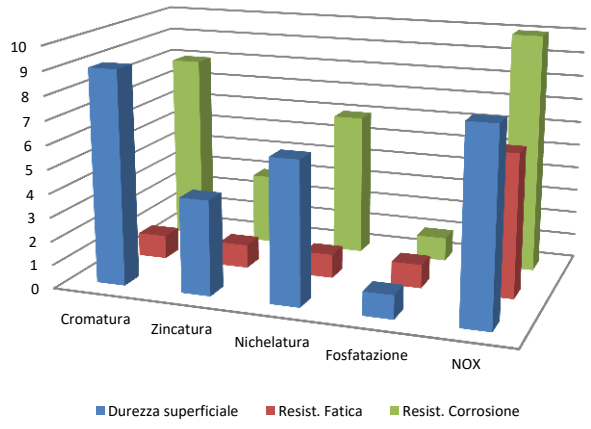
NITRICAT-NOX FEATURES AND BENEFITS

The most significant features that distinguish the NITRICAT-NOX® treatment from competitor treatments, such as galvanizing, are certainly:

- ✓ High surface hardness up to 1200 HV1
- ✓ Case hardening depth up to 0.7 mm
- ✓ Wear and friction resistance
- ✓ Increase of fatigue limit
- ✓ Reduction of friction coefficient
- ✓ Smooth and uniform black coating
- ✓ Increase of corrosion resistance up to 500h (ASTM B117)

Unlike galvanic treatments (i.e. Zinc plating, Chrome plating, Nickel plating), in which layer is deposited on the workpiece, the protective layer developed during the NITRICAT-NOX® treatment grows starting from the basic material, ensuring a whole series of benefits such as:

- ✓ Absence of defects
- ✓ High adhesion
- ✓ No need of surface preparation
- ✓ All round effect even on complex geometry, holes or narrow cavity



Properties comparison of NITRICAT-NOX vs. other surface treatments

In comparison to conventional nitriding post-oxidation treatments, the NITRICAT-NOX® process is conducted entirely in the gaseous atmosphere with the aid of NitriCat technology, a combination that produces a series of advantages such as:

- ✓ Lower treatment temperature respect the traditional nitriding treatment
- ✓ Less deformation
- ✓ Accurate control of metallurgical characteristic
- ✓ Uniformity of all surfaces
- ✓ Low roughness increase thanks to gas process
- ✓ Flexible process of all the parts, small or giant mechanical components

ENVIROMENTALLY FREINDLY

The subject of environmental impact is becoming increasingly important in the development of industrial processes, in particular the implications that industrial products have on human health and the environment.

Contrary to the processes in baths of molten salt or to those of electrodeposition, which use highly harmful substances, the NITRICAT-NOX® process does not produce substances toxic to man and the environment.

The gases used during the process are suitably converted into inert chemical species (hydrogen, nitrogen, water); both during the process itself and before entering into the atmosphere. Therefore not producing expensive and problematic to dispose waste, in addition to the environmental impact, it is a considerable saving on production costs and management of the entire process.

Many electrochemical plating containing, and especially Chromium plating containing Cr^{6+} will be soon forbidden in many applications the NITICAT-NOX process is the best choice to replace these treatments because of it properties and higher performance.

The NITICAT-NOX is safe for the environment and for humans which work and use it, for this reason it works also in interior design and food industries applications.

CONTACT US:

Colmegna Nord srl
Via Cavalcabò 13
38068 Rovereto (TN) - ITALY
Tel. 0464 83 45 06
info@colmegnanord.com