NITREG® STATE OF THE ART CONTROLLED GAS NITRIDING TECHNOLOGY

Nitrex Metal Technologies Inc. (“NMT”) offers a state-of-the-art controlled gas nitriding technology which has considerable advantages over conventional gas nitriding, ion (plasma) and salt bath nitriding because of its unique process control capabilities.
This new technology is used to improve performance and durability of parts and tooling without distortion while at the same time substantially reducing costs.

CONVENTIONAL NITRIDING vs. NITREG® NITRIDING

Nitriding is a process of enriching the surface layer of steel with nitrogen, resulting in the formation of a hardened surface with improved fatigue, wear and/or seizing resistance on machine components or tools [dies, moulds, etc.]. The depth, structure and properties of the surface layer depend on the particular alloying elements contained in the steel and on the processing variables.

There are two distinct approaches in present-day gas nitriding:

Conventional nitriding, carried out in an atmosphere containing partially dissociated ammonia gas at 500-600°C (930-1110°F). In this process, the superficial nitrogen concentration cannot be adequately controlled. The combined nitrogen and carbon concentration at the surface may increase to over 11 wt %, causing oversaturation of the superficial compound zone, popularly known as the “white layer”. This white layer, obtained by the conventional nitriding process, may be (and often is) excessively porous and brittle because of the high nitrogen concentration.

An example of the microstructure of a conventionally nitrided component is shown in Fig. 1.

Fig. 1. Microstructure of conventionally nitrided steel. Note the sizable porous outer layer.

The superficial zone of the nitrided case in steels subjected to conventional gas nitriding consists of two phases: the outer epsilon type carbo-nitride and a deeper situated gamma prime nitride. The epsilon phase contains a porous zone at the surface, the extent of which cannot be predicted or controlled in a conventional process.

The epsilon zone, obtained in a conventional process is hard and wear resistant only in its underlying compact zone, while the external porous zone has lower hardness, is brittle and has spalling tendencies. In many applications it requires grinding off or removal by other means before the component can be used, thus adding to the overall manufacturing cost.

It is important to underline the fact that the white layer is very beneficial in many applications (increased corrosion resistance and better lubricity) if the porosity is appropriately controlled. Nitreg® nitriding technology has the unique capability to control the porosity and the quality of white layer.

In addition, because of inadequate process control, conventional gas nitriding cannot guarantee repetitive and consistent results from one process to another.

The inherent properties of the Nitreg® process render it highly competitive compared to other surface hardening methods, such as salt bath and ion nitriding.

The Controlled Nitreg® process assures a precisely controlled nitrogen concentration at the surface of the component, which cannot be achieved by conventional gas nitriding, ion nitriding or salt bath nitriding. This results in high endurance and wear properties of the processed machine parts or tools, with no need for subsequent grinding and cleaning. The Nitreg® process is in itself more economical than conventional gas nitriding. The long diffusion cycle necessary in the conventional nitriding process is optimized through the use of Nitreg® computer control, resulting in shortened cycle times and substantial cost reduction.

Furthermore, the Nitreg® process can be custom tailored to suit the properties of a wider selection of materials, ranging from plain carbon to stainless steels. All major advantages of gas nitriding, such as negligible dimensional changes and the relatively low treatment temperature, are retained in the Nitreg® process. Thus, it is a viable replacement for carburizing. Therefore, components can be nitrided in the quenched and tempered condition for enhanced core hardness.

The dimensional stability is achieved because there is no occurrence of thermal shock to the processed part, as with the salt bath process. The load is heated from ambient up to process temperature then cooled back down to ambient, all within the sealed furnace vessel. The most important advantage of Nitreg® controlled process is that the white layer is not brittle, while retaining same hardness. An added advantage is the capability of consistently repeating the same nitriding results for each given application, and within the same load due to the extremely tight temperature control during the process and excellent circulation of the gaseous atmosphere attainable within the well-designed nitriding vessel.

THE PRINCIPLE OF THE NITREG® PROCESS

The Nitreg® process can be characterized by the use of the nitriding potential of the furnace atmosphere as the controlling parameter. The nitriding potential is expressed by the following formula as the ratio of partial pressures of ammonia and hydrogen:

$$K_n = \frac{pNH_3}{(pH_2)3/2}$$

Depending on the grade of steel, this parameter is maintained at a preset constant value ranging from 0.5 to 15 for a processing temperature between 500 and 600°C (932- 1112°F). To optimize the case properties and process time, the nitriding potential can be programmed to different values for the different stages of the treatment.

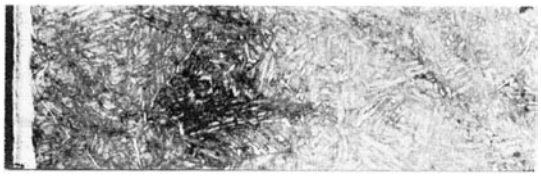
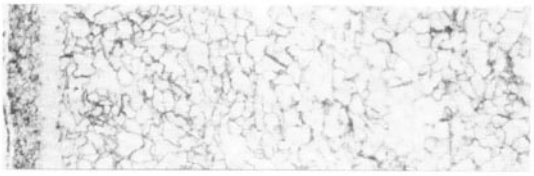
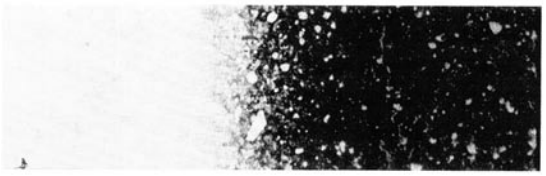
A controlled rate of cooling after treatment inhibits the formation of undesirable nitrides or carbonitrides at grain boundaries in the diffusion zone, thus increasing the toughness of the case.

STRUCTURES AND PROPERTIES OF THE NITRIDED CASE

With the emergence of controlled gas nitriding, it was found that zones with preprogrammed nitrogen concentrations had superior tribological properties, negligible dimensional changes and high hardness. In everyday practice we can identify three types of nitrided layers. The examples of such nitrided microstructures, as produced by the Nitreg® process are presented in Table I.

INDUSTRIAL APPLICATIONS OF NITREG® GAS NITRIDING

TABLE 1

TYPE	NITRIDED LAYER	MICROSTRUCTURE
Type 1 -	used for various types of alloyed steels with the surface [white layer] containing controlled amounts of nitrogen.	
Type 2 -	used for various types of carbon steels with the surface [white layer] containing controlled amounts of nitrogen.	
Type 3 -	used for tool steels without the surface [white layer].	

Superficial hardness values for some Nitreg® nitrided steels quenched and tempered prior to nitriding are given in Table II.

TABLE II

Grade of Steel	Hardness HV after nitriding with approximate conversion to HRC.	
AISI 1045	450 – 550 HV1	(44 – 52 HRC)
AISI 4140	650 – 700 HV10	(58 – 61 HRC)
NITRALLOY 135M	750 – 1100 HV30	(> 62 HRC)
H 13	1000 – 1100 HV1	(>68 HRC)

The Nitreg® gas nitriding process can be applied to practically any grade of structural steel, many tool steel grades, stainless steel, and cast iron.

The following list indicates steel grades that have been successfully processed in industrial conditions and field tested with favorable results:

Nitriding Steel:	Nitralloy 135M, Nitralloy N and equivalents
High Speed Steels:	AISI M2, M36, M42
Tool Steels:	D2, H11, H13, A10, A2, S7
Carbon Steels:	1045, 1008, 1010, 1020, 1045, 1060, “free machining”, “stress proof”
Alloy Steels:	4130, 4140, 4330V, 4340, 5130, 5140, 8620, 9310
Stainless Steels:	300 and 400 series
Cast Irons:	Ductile, Grey

Typical applications of the Nitreg® method include stampings, forgings, castings and machined parts used in machinery, defense, aerospace, automotive, tool and die, oil drilling, mining and paper mill industries. These parts processed with the Nitreg® treatment have a higher surface hardness than parts treated by conventional heat treatment. The service life of Nitreg® treated tools can be increased by 50 - 100%.

Many of our customers have chosen Nitreg® as a replacement for carburizing, ion nitriding or salt bath nitriding, reaping the benefits of no distortion and elimination of costly finish grinding. As an example, a diesel engine manufacturer who replaced conventional gas nitriding of crankshafts with Nitreg® gas nitriding was able to shorten the time required for the finishing operation by 75%. Another customer migrated to Nitreg® technology from ion nitriding to alleviate the problem of non-uniform nitriding at the root of the gear teeth and in recessed cavities.

The NMT representative in your area will be pleased to review your application and provide recommendations for the treatment of components with the Nitreg® technology as well as a list of applications in the automotive, aerospace, tool and die, aluminium extrusion and other industries.

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