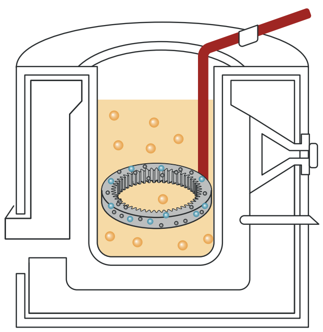
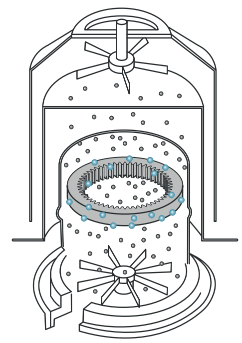
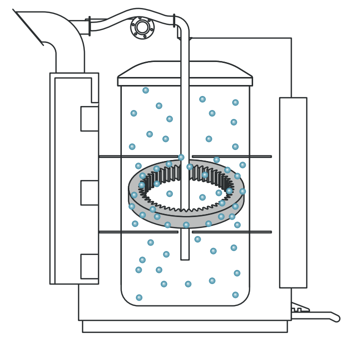
Comparison

of nitriding methods for stainless steels

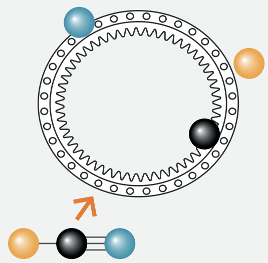
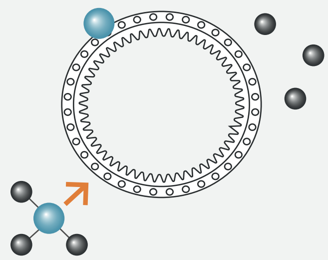
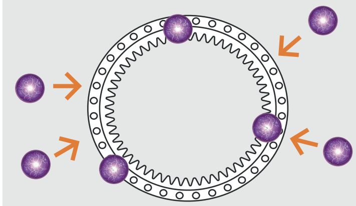






NITRIDING METHOD	SALT BATH NITRIDING	GAS NITRIDING	PLASMA NITRIDING
ATMOSPHERE	Molten cyanide salts.	Gaseous atmosphere (typically dissociated ammonia).	Glow discharge in controlled atmosphere.
PROCESS DESCRIPTION	Parts are immersed in a cyanide-based salt bath. This bath contains compounds such as sodium cyanate (NaCNO) and sodium cyanide (NaCN), which thermally dissociate. Cyanide acts as the nitrogen source (and also some carbon), which diffuses into the steel surface.	Gas nitriding is carried out by placing the parts in a furnace with an ammonia-rich atmosphere (NH_3). Ammonia partially dissociates into hydrogen and atomic nitrogen, and this nitrogen diffuses through the steel surface.	Inside a vacuum chamber, a high-voltage electric field is created between the parts (cathode) and the furnace walls (anode). The atmosphere, composed of nitrogen (N) and hydrogen (H) gases, is ionized by the current and forms an active plasma. The ions accelerated by the electric field bombard the surface of the parts, and nitrogen penetrates by diffusion.

ABC of stainless steels
And why plasma nitriding is the best way to harden them without damaging their corrosion resistance

	SALT BATH NITRIDING	GAS NITRIDING	PLASMA NITRIDING
PRINCIPLE	 **NaCN** **Cyanide salt diffusion** The thermal reaction dissociates the salts and releases active nitrogen species: **$4NaCNO \rightarrow 2NaCN + Na_2CO_3 + CO + 2N$** **$3Fe + 2CO \rightarrow Fe_3C + CO_2$** These species enable the formation of a nitrided layer, with high nitride and cementite (Fe_3C) content, particularly in carbon steels.	 **NH3** **Ammonia diffusion** Ammonia decomposes upon contact with the hot steel surface: **$2NH_3 \rightarrow 2N + 3H_2$** Atomic nitrogen adheres and diffuses into the surface layer of the material, generating compounds such as iron nitrides ($Fe_{2-3}N$), responsible for increased hardness.	 **N+** **Nitrogen ion bombardment** *Electrically charged gas* At low pressure (1–10 hPa) and with a potential difference of 300–1000 V, the gas transforms into plasma: **N_2 + energy $\rightarrow 2N^+ + e^+$ (ionization)** → Ions accelerate toward the cathode (the parts), producing sputtering cleaning, surface activation, and nitrogen entry in an atomic, highly reactive state.
TEMPERATURE	TYPICAL RANGES FOR CARBON STEELS:		
	570 - 620 °C 1058 - 1148°F	**520 - 600 °C** 968 - 1112°F	**350 - 600 °C** 662 - 1112°F
	PASSIVE LAYER DEGRADATION LIMIT IN STAINLESS STEELS: **450 – 470 °C** = 842 – 878°F		

APPLICATION IN STAINLESS STEELS

SALT BATH NITRIDING

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Not advisable

Not ideal. Although it can form a hard layer, the process severely damages the natural passivation of stainless steel.

Salts interfere with the chromium oxide layer, causing localized attack (pitting) that compromises corrosion resistance.

In addition, the carbon that diffuses along with nitrogen may form chromium carbides, further reducing the material's corrosion resistance.

GAS NITRIDING

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High-risk without tight control

The process must be handled with extreme care. If the temperature exceeds a certain threshold or the atmosphere is not properly controlled, chromium nitrides may form at the grain boundaries, reducing the free chromium content and compromising corrosion resistance.

Also, no well-defined compound zone is formed, and the hardness achieved may be lower than with other, more controllable methods.

In most cases, an additional step is required: post-oxidation. This regenerates the chromium oxide layer and improves corrosion resistance, although it rarely restores it completely.

PLASMA NITRIDING

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Best option

This is the ideal treatment. Thanks to the low temperature at which it can be performed (~400 - 450 °C) and the precise control of the environment, chromium nitrides do not form and the passive layer is preserved.

Plasma nitriding hardens the surface without affecting corrosion resistance, maintaining the base structure of stainless steel.

Furthermore, since no carbon is used in the atmosphere, the risk of grain sensitization is completely avoided.

The result is a hardened zone by expanded austenite (S-phase), clean, uniform, and suitable for demanding environments such as pharmaceutical, medical, food, or marine.

No post-oxidation required.