Tribological advantages of nitrocarburizing over carbonitriding: influence of the composition and architecture of the compound layer.

P- F. Cardey[1*], A. Fleurentin[2]

[1)] Pôle Matériaux Métalliques et Surface, CETIM Saint Etienne, F42952 Saint Etienne Cedex, France.
[2)] Pôle Matériaux Métalliques et Surface, CETIM Senlis, F60300 Senlis, France.

[*]Corresponding author for tribo-lyon2013@sciencesconf.org

Abstract:

Nitrocarburizing and carbonitriding are two thermochemical treatments for surface hardening of steel parts using diffusion of carbon and nitrogen.

By carbonitriding, hardening is obtained by martensitic transformation, which requires process temperature from 800 up to 850°C.

By nitrocarburizing, hardening is obtained by precipitation of nitrides and carbonitrides at temperatures near to 570°C. Moreover, nitrocarburizing leads to the formation in surface of a compound layer (called "white layer" – see figures 1 and 2) composed of iron nitrides γ' (Fe_4N) and ε ($Fe_{(2,3)}N$). It is this non-metallic layer that gives tribological behaviour to nitrocarburised steel.

Fig. 1: Surface of carbonitrided steel.

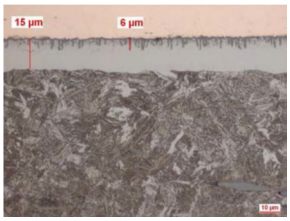

Fig. 2: Surface of nitrocarburised steel. Compound layer with "columnar" porosity

Less common than carbonitriding, nitrocarburizing would occupy 4% of market share in France while carbonitriding would have 80% [1]. To help manufacturers to choose between these two processes, the CETIM committee "Heat treatments and dry coatings" leads a study on the tribological behaviour of these thermochemical treatments.

A former study (2010) has shown the tribological benefits of nitrocarburizing for heavily loaded lubricated contacts (1 800 MPa) [2]. This current study concerns less loaded contacts (830 and 1430 MPa) in order to dissociate the two treatments in dry friction and to better understand the role of compound layer on friction and wear.

Carbonitriding has been compared to 8 nitrocarburizing with different type of compound layer (thickness, porosity, proportion of nitrides γ' and ε, post-oxydation). The grade of steel used is a 27MnCr5 pretreated to 33 HRC (grade commonly used in automotive industry at carbonitrided state).

The results of dry friction tests show that nitrocarburizing leads to decrease from 20 to 40% the friction coefficient by comparison with carbonitriding. The wear decrease from 60 to 80% thanks to anti-seizure role of the compound layer. For lubricated contact, advantages of nitrocarburation concerns the kinetic of formation of the lubrification film.

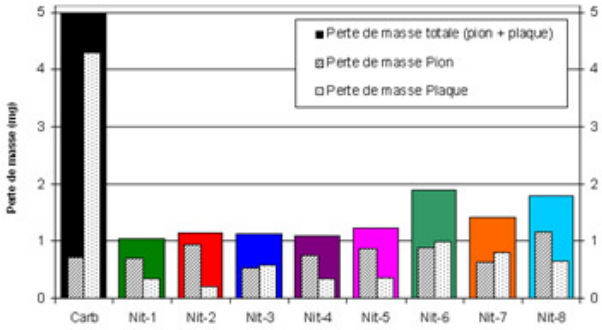

Fig. 3: Specimens mass loss after dry friction tests

This study also highlighted the role of the compound layer architecture (porosity, thickness and nitrides nature of the layers, roughness, wettability) on the tribological behaviour of nitrocarburizing layers.

References

[1] Belot J-M., Peyre J-P., "Technique de durcissement dans l'automobile", Note de veille revêtement et traitements de surface (2007).

[2] Cardey P-F., Fleurentin A., "Intérêts tribologiques de la nitrocarburation vis-à-vis de la carbonitruration pour des contacts acier/acier", Traitements & Matériaux, 404 (2010).

[3] Sola R., " Effeto della morfologia superficiale sulla resistenza a usura e a corrosion dell'acciaio 41CrAlMo7 nitrurato, nitrocarburato e post-trattato", La Mettallurgia Italiana, 5 (2010).

[4] Chiu L.H., Wu C.H, Chang H., "Wear behavior of nitrocarburized JIS SKD61 tool steel", Wear (2002).