Nanoindentation measurements in plan view and cross section in a nitrided maraging steel: relation between hardness and nitrogen concentration

Joan Josep Roa Rovira[1], Christophe Tromas*†[1], and Luc Pichon[1]

[1]Institut Pprime (PPRIME) – CNRS : UPR3346, Université de Poitiers, ENSMA – Département de Physique et Mécanique des Matériaux SP2MI - Téléport 2 - Boulevard Marie et Pierre Curie - BP 30179 86962 Chasseneuil- Futuroscope Cedex, France

Abstract

Maraging steels are very high strength steels which also offer a range of complementary properties, such as high fracture toughness, good weldability and easy machinability, enabling them to be employed in many applications. Their fatigue resistance can be improved by nitriding treatments.

The objective of this study is to characterize, at the nanometer scale, the surface mechanical properties of maraging steel samples after different thermal treatments and nitriding processes. The nitrogen concentration profile in the nitrided layer has been determined by Glow Discharge Optical Emission Spectroscopy (GDOES) and compared to the hardness and elastic modulus profiles. These profiles have been established at the nanometer scale, by means of the U-NHT nanoindenter from CSM Instruments, which uses an active surface reference. The thickness of the maraging steel samples was of about 190 μm while the nitrided layers ranged from 5 μm to 30 μm according to the thermal treatment and the nitriding process parameters. Two different and complementary experimental approaches have been used. Nanoindentation arrays have been first performed in cross section, after embedding the maraging steel sheets, edge on, in a resin matrix. In order to achieve a high spatial resolution in the mechanical properties profile, 100 nm deep indents were performed. Furthermore, in order to keep the same indentation conditions along the nitrogen concentration profile, whatever the hardness value, the experiments have been performed in displacement controlled mode, with a total penetration depth of 100 nm.

In a second time, nanoindentation measurements have been performed in "plan view" on the nitrided surface. Thin surface layers have been then progressively removed by chemo-mechanical polishing, and successive nanoindentation measurements have been performed after each polishing stage, along the nitrogen concentration profile. The thickness of the removed layer has been monitored by observing by Atomic Force Microscopy (AFM) the evolution of large microindents all along the successive polishing stages.

The combined study of the hardness profile across the nitrided layer in plan view as well as in cross section, and of the nitrogen concentration profiles, as determined by GDOES, allowed to build a Hardness vs Nitrogen concentration curve. This curve is analyzed and discussed of nitriding mechanisms.

*Speaker

†Corresponding author: christophe.tromas@univ-poitiers.fr

Keywords: nanoindentation, maraging steel, hardness, nitriding