Multi-instrumented in-situ measurement of strain induced martensitic transformation in medium Mn stainless steels

Gwendal Lagorce*[1], Bastien Durand[1], and Olivier Hubert[1]

[1]Laboratoire de Mécanique Paris-Saclay – Université Paris-Saclay, CentraleSupélec, ENS Paris-Saclay, CNRS, LMPS - Laboratoire de Mécanique Paris-Saclay, 91190, Gif-sur-Yvette, France., Université Paris-Saclay, CentraleSupélec, ENS Paris-Saclay, CNRS, LMPS – Laboratoire de Mécanique Paris-Saclay, 91190, Gif-sur-Yvette, France, Université Paris-Saclay, CentraleSupélec, ENS Paris-Saclay, CNRS, LMPS - Laboratoire de Mécanique Paris-Saclay, 91190, Gif-sur-Yvette, France. – France

Abstract

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The existence of an austenite-martensite phase transformation while undergoing plasticity gives excellent properties to unstable stainless steels (e.g. AISI 301 grades). Understanding and monitoring this phenomenon is essential for the development/validation of constitutive laws. Since austenite is paramagnetic whereas martensite is ferromagnetic, magnetic measurements allow for the estimation of martensite content. Well-suited in-situ systems usually involve permeameters to perform such measurements where a primary coil ensures magnetization, and a pick-up coil measures the material magnetic response. However, those systems forbid deformation and thermal full field measurements. On the other hand, previous work has shown that a non-contact fluxgate magnetometer can be used to monitor magnetic behavior variations without magnetization coils (1). It is a lightweight system that gives access to surfaces and therefore allows field measurements. Given the exothermic nature of the phase transformation, measuring temperature field could provide additional knowledge allowing for more accurate modeling. The present study aims to evaluate feasibility of using a non-contact fluxgate sensor to measure martensite volume fraction variations and make a correlation with mechanical and thermal fields.

Three grades of 1.5mm thick medium Mn stainless steel sheets have been considered exhibiting different austenite stabilities (thanks to variable compositions). Monotonic tensile tests have been then performed at a low strain rate (10–4 s–1) at room temperature using a hydraulic testing machine. Full field displacement and temperature measurements have been carried out using Digital Image Correlation (DIC) and Infrared Thermography (IRT). The magnetic response of the material and its environment has been evaluated during the tests using a 1D-axis fluxgate magnetometer designed for weak magnetic field measurements with a range of ± 200 μT.

Both DIC and IRT captured the propagation of Lüders and Portevin-le-Châtelier bands, associated with oscillations of the tensile stress. The higher the austenite stability the higher

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*Speaker

the strain threshold at which bands propagation begins. The magnetic measurements showed a global increase of the magnetic signal at increasing deformation, in accordance with previous experiments (2). Field measurements allowed to demonstrate a clear correlation between bands propagation and martensite content. Results will be used as validation tests of a fully coupled thermomechanical modeling of these materials.

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