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► **To cite this version:**

Olivier Hubert, Z. Maazaz, Julien Taurines, Raphael Crepinge, Frenk van den Berg, et al.. Influence of biaxial stress on magnetostriction - experiments and modelling. 25th Soft Magnetic Materials - SMM25, May 2022, Grenoble, France. hal-03773040

HAL Id: hal-03773040

<https://hal.science/hal-03773040>

Submitted on 8 Sep 2022

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Influence of biaxial stress on magnetostriction – experiments and modelling

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The study takes place in the context of in-line non-destructive testing of steels and the development of magneto-mechanical models that it requires. New magnetic and magnetostrictive measurements of a steel submitted to biaxial mechanical loading are presented. They allow validation of the proposed models.

Keywords: biaxial stress, magnetostriction, multiscale modelling

1. Introduction

In the last few years, a growing interest of the car industry for the use of Advanced High Strength Steel (AHSS) products has been observed, especially considering the weight saving solutions they lead to. Their excellent mechanical behaviour comes from the very complex microstructure they exhibit, achieved thanks to precise thermomechanical treatments. They are on other hand highly sensitive to small variations in the forming process. *On-line* non-destructive magnetic monitoring techniques are consequently relevant to evaluate the quality fluctuations.

2. objectives

On-line monitoring faces different issues. One of them concerns the multiaxial mechanical stress to which the laminations are submitted, that may have a strong effect on the magnetic behaviour [1] and may lead to erroneous estimations of the microstructure quality. Developing multiaxial experiments and multiaxial magneto-mechanical models for inverse identification is therefore relevant. Previous works have addressed magnetic behaviour change due to multiaxial stress, including dual-phase steel [2,3,4]. In this communication, some new results showing the effect of a biaxial stress on the magnetostrictive behaviour are presented.

3. Measurement and modelling

A flat carbon Steel (thickness ~3mm) is considered in this study. Its post hot-rolled state ensures isotropic global magnetic and mechanical behaviours. 1D samples consist of 200mm long and 12mm wide strips cut by electro-erosion machining. 2D samples are cross-shape specimen designed to promote homogeneous stress and magnetic field in the central area. Samples have been instrumented with longitudinal and transverse strain gauges, pick-up coil for 1D samples and H-coil and needle-B for the 2D samples. Magnetic and magnetostrictive measurements are performed under quasistatic and anhysteretic conditions

and for a large range of stress levels. Among other results, it is shown that the magnetostriction amplitude isovalues seem to follow a rule different from the susceptibility isovalues (fig.1). Results are compared step by step to the output of a multiscale model taking account the crystallographic texture and phases volume fraction [1-5]. Measurement and modelling are found to be in agreement. These comparisons give some keys for a future inverse identification procedure.

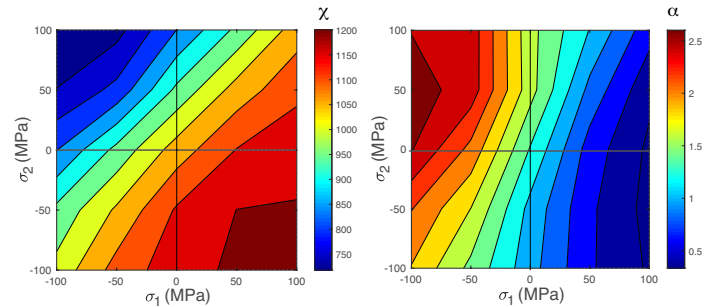


Figure 1 : magnetic susceptibility χ and magnetostriction amplitude parameter α as function biaxial stress state (σ_1 , σ_2) for magnetic field applied along direction 1.

Acknowledgement

This project has received funding from the Research Fund for Coal and Steel under the grant agreement N° 847296.

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