On the measurement of Giant Magnetostrictive Material properties under mechanical loading

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ABSTRACT

Giant Magnetostrictive Materials (GMM), such as Terfenol-D or Galfenol, can be integrated in actuator or sensor applications. The design of these systems is optimized based on a good knowledge of the material properties [1, 2]. Under standard operating conditions, GMM are subjected to stress. It is therefore important to characterize their properties under mechanical loading. Obtaining these data requires to apply simultaneously a magnetic and a mechanical loading. In the case of a strong magneto-mechanical coupling as observed in these materials, these loadings strongly interact, and it is particularly noticeable that the magnetic loading affects the mechanical boundary conditions on the sample [3, 4].

Recently, an experimental setup dedicated to the characterization of GMM magneto-mechanical behaviour under constant stress has been designed [5]. This setup is able to reduce the dynamic stress variations induced by magnetic excitation variations below 0.1 MPa. The present work focuses on the effect of loading boundary conditions on the measurement of magnetic and piezomagnetic properties of Terfenol-D under stress levels from 0 to 90 MPa.

By comparing the results obtained under controlled and uncontrolled stress conditions, it is shown that uncontrolled boundary conditions can be responsible for errors of several percent on the measurement of the maximum and remnant magnetic induction. The measurement of strain is even more sensitive to the boundary conditions, with errors up to 40% and 30% on the longitudinal and transverse strain, respectively. In addition, errors on the measurement of susceptibility and piezomagnetic properties of the material are quantified.

This work highlights the utmost importance to precisely control the boundary conditions for an accurate characterization of GMM properties under mechanical loading.

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