7th ECCOMAS Thematic Conference on Smart Structures and Materials
SMART 2015
A.L. Araújo, C.A. Mota Soares, et al. (Editors)

Abstract ID-008

PHENOMENOLOGICAL AND PHYSICALLY MOTIVATED CONSTITUTIVE MODELS FOR FERROMAGNETIC AND MAGNETOSTRICTIVE MATERIALS

Artjom Avakian, Andreas Ricoeur

Institute of Mechanics, University of Kassel, Germany
artjom.avakian@uni-kassel.de ; ricoeur@uni-kassel.de

Keywords: Ferromagnetics, Magnetostriction, Hysteresis Loops, Nonlinear Constitutive Modeling

Summary: The coupling of magnetic and mechanical fields due to the constitutive behavior of a material is commonly denoted as magnetostrictive effect. The latter is only observed with large coupling coefficients in ferromagnetic materials, where coupling is caused by the rotation of the domains as a result of magnetic (Joule effect) or mechanical (Villari effect) loads. However, only few elements (e.g. Fe, Ni, Co, Mn) and their compositions exhibit such a behavior.

In this paper, the theoretical background of nonlinear constitutive multifield behavior as well as the Finite Element (FE) implementation are presented. Nonlinear material models describing the ferromagnetic behavior are presented. Both physically and phenomenologically motivated constitutive models have been developed for the numerical calculation of the nonlinear magnetostrictive behaviors. On this basis, magnetization strain and stress are simulated and the resulting effects analyzed. The phenomenological approach covers reversible nonlinear behavior as it is observed e.g. in cobalt ferrite. Numerical simulations based on the physically motivated model focus on the calculation of hysteresis loops and the prediction of local domain orientations and residual stress going along with the magnetization process.

Final goal is the implementation of this behavior together with an existing ferroelectric constitutive model, to improve the efficiency of magnetoelectric coupling in multiferroics and to reduce damage associated with the coupled poling process. Further, the developed tools enable the prediction of the electro¬magneto¬mechanical properties of smart multiferroic composites and supply useful means for their optimization. The resulting final state of a poling simulation can be implemented as a starting condition for approximate linear simulations and multifield homogenization procedures.