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Stability of magnetoactive composites with periodic microstructures undergoing finite strains in the presence of a magnetic field

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Abstract

We investigate the macroscopic magnetomechanical instabilities in magnetorheological elastomer (MRE) composites undergoing finite strains in the presence of a magnetic field. In particular, we identify the unstable domains for MRE composites with periodically distributed circular and elliptical inclusions embedded in a soft matrix. We use the isotropic Langevin model for magnetic behavior, to account for the initial (linear) susceptibility and saturation magnetization of the magnetoactive inclusions. We analyze the influence of the applied magnetic field and finite strains, as well as particle shape and material properties, on the stability of the MRE composites. We find that the stable and unstable domains can be significantly tuned by the applied magnetic field, depending on deformation, microstructure and magnetic properties of the inclusions such as initial susceptibility and saturation magnetization.

Keywords: Magnetorheological elastomers, Stability, Composites, Finite Deformation, Microstructure

1. Introduction

Magnetorheological elastomers (MREs) are materials that can change their mechanical behavior in response to application of an external magnetic field. Recently, these materials have attracted significant attention due to their relatively simple, remote and reversible principle of actuation making them suitable for various applications. Potential applications include remotely controlled actuators [61, 12], variable-stiffness devices, tunable vibration absorbers and damping components [28, 15, 41, 33], noise barrier system [23] and sensors [62] among others.

Typically, MREs are composite materials that consist of magnetizable particles embedded in a soft matrix material. A polymeric matrix material (e.g. silicone rubber) in its liquid state before polymerization, is mixed with magnetizable particles (of micro or even nano size) such as iron (cobalt, nickel, or Terfenol-D) magnetizable powder [35].

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