Numerical characterization of Magnetostrictive response of GalFeNol samples for Energy Harvesting

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Introduction: GalFeNol is a new Giant Magnetostrictive Material that can be used in energy harvesting especially in vibration reduction applications, thanks to the Joule and Villari effects [1,2]. This material [3] has a high Ultimate Tensile Strength of 360 Mpa, so it can work under tensile stress conditions, increasing mechanical reliability. Finally, this material is very light (density 7800 kg/m3).

Computational Method: The equations are

$$\varepsilon_{33} = \frac{\sigma_{33}}{E} + d_{33}H$$

$$B = d_{33}\sigma_{33} + \mu H$$

Where ε_{33} and σ_{33} are longitudinal strain and stress; B and H are induction and magnetic field; d_{33} and μ are piezomagnetic and permeability constant; E is Young's modulus.

A 3D-model of GalFeNol rod is stressed by a time varying longitudinal force of 1000 N. The study has been carried out for two shapes, a solid and hollow cylinder (Figure 1). For both shapes, physical dimensions (inner and outer radius) are parameterized in order to evaluate the best combination of them. The model also includes a multiple wire coil and a resistive load (100 Ω) to evaluate the electrical power generated by the energy harvesting.

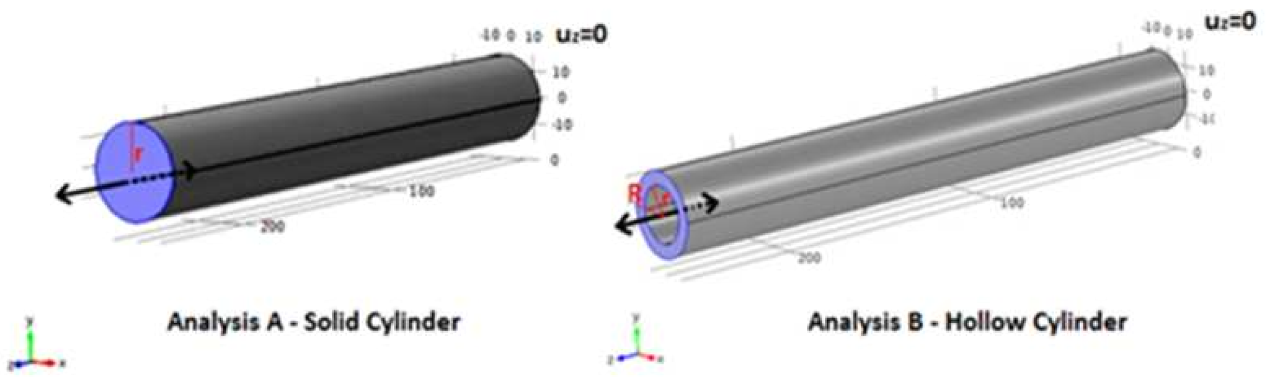

Figure 1. Solid and hollow cylinder

Results: In mechanical terms, results show that the maximum longitudinal strain is 80.0 ppm for the solid cylinder, and 36.0 ppm, for the hollow cylinder. In terms of magnetic energy conversion, both from the parametric results for solid cylinder and for hollow cylinder (Figure 2), the conclusion is that the smaller the transverse section, the higher the converted electrical power.

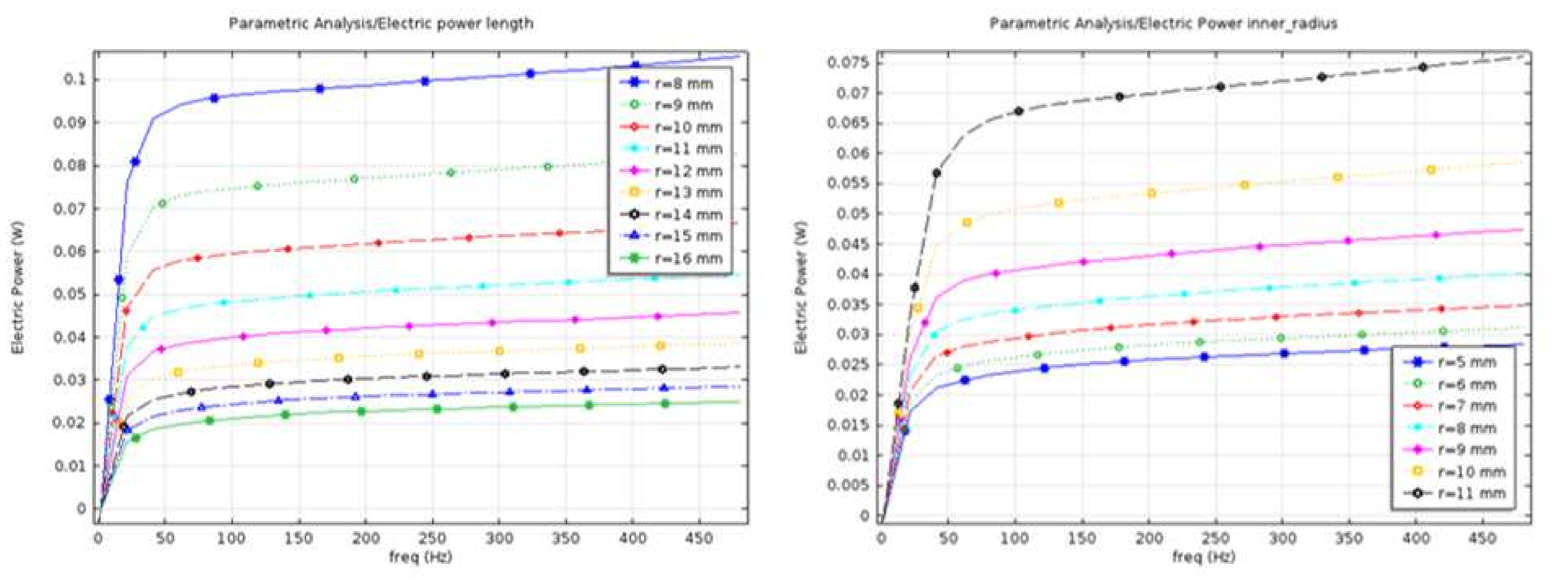

Figure 2. Parametric analysis: solid and hollow cylinder

Conclusions: The GalFeNol is able to convert mechanical energy into electric one and at the same time to resist to mechanical stress, indeed the maximum computed internal stress is below 10 % of UTS. Future studies will deal with more complex 3D-models, taking into account the actual nonlinear behavior of such alloys, and more efficient electric circuits to improve energy conversion efficiency.

References:

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