Computational Modeling of Magnetorheological Elastomers Using Soft and Hard Magnetic Particles

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Introduction

Magnetorheological Elastomers (MREs) are a composite that consist of magnetic micrometer sized particles suspended within rubber matrix filler. By placing this material within an external magnetic field during the rubber curing process, the poles of the particles are forced to align and form chains of particles within the matrix. These chains cause the MRE to change its stiffness properties when an external magnetic field is applied. In this paper both iron and Barium Hexaferrite (BaM) were used as the magnetic filler particles. Iron is a "soft" magnet; its individual magnetization is reliant on the external magnetic field and is very easily changed. BaM is a "hard" magnet, and has its own magnetization independent of any external field. This difference causes these particles to behave radically different when used within MRE composites. This paper will study how these particles behave differently under combined shear loading and an external magnetic field.

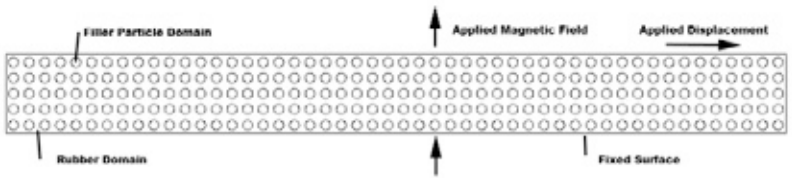

Figure 1: Problem Schematic

Use of COMSOL Multiphysics

In order to accurately portray this model, both the Plane Stress module and AC/DC module will be used. The plane stress module will be used to apply a shear displacement along the top surface of the sample while the bottom surface remains fixed. Modulus values will be assigned for both the particles and the matrix filler material. The AC/DC module will be utilized to apply the external magnetic field. Magnetic properties will be given to the particles and filler. By changing the sub-domain properties of the particles, the model differentiates between the magnetic properties of the Iron and the BaM. By integrating the traction across the sheared surface for increasing proscribed displacements, the macroscopic and local behavior of BaM and Iron based MREs will be studied.

Conclusion

Experimental results show that the Barium Hexaferrite material yields larger surface tractions than the iron particles. Magnetorheological Elastomers show great possibility for use in system dynamic control applications. However at this point, the magnetic fields necessary to make them useable are large. By finding a more reactive magnetic particle or by optimizing particle arrangements, lower fields can be used and MRE's may prove to be more useful in application.