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Analytical modeling of electrical conductivity and magnetic permeability of magnetorheological elastomers

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In this work, the analytical homogenization method is used to model electrical conductivity and magnetic permeability of magntorheological elastomers (MREs). MREs are considered as spherical particulate composites of infinite matrix and spherical particles, composed of simple cubic (SC), body-centered cubic (BCC), and face-centered cubic (FCC) lattices. The analytical homogenization method is used in this work, which combines multiscale method and asymptotic techniques in order to solve for effective conductivity and permeability of MREs. The effect of cluster formation, and particles volume fraction are also discussed as it reaches percolation threshold. Additionally, the impact of external mechanical loads and magnetic field are considered in the solution. The edge effects corresponding to redistribution of the load between components are also considered, which plays an important role in nonhomogeneous composite materials. The employed edge effect model shows good results for transversely isotropic composites, which correspond to aligned MREs with chain-like structures. The analytical solution shows similar behavior of electrical conductivity and magnetic permeability under external loadings or changes in volume fraction. External mechanical loads and magnetic fields show increase in both electrical conductivity and magnetic permeability in particulate composites, although with different rate. Furthermore, the obtained analytical solution in this work, especially the ones obtained for the SC lattice structure, is in good correlation with the results of previous experimental studies obtained for aligned MREs.

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