Multiscale modeling of nearly incompressible polymer composites

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Heterogeneous materials are created as a combination of two or more constituents and possess enhanced properties [1]. As a result of their improved properties, heterogeneous materials are employed in many applications, including automotive industry, aircrafts, biomedical engineering, wind turbines [2]. Two main classes of heterogeneous materials are known as polycrystals and matrix composites. In particular, the microstructure of matrix composites consists of a continuum phase (matrix), which can be made of polymeric or metallic or ceramic, and of inclusions distributed in the matrix. Matrix composites with a polymer matrix, known as polymer matrix composites (PMC). The properties of particulate PMCs highly depend on the filler material and their arrangement, which affect the mechanical, thermal, and electrical properties of PMCs.

In the present work, an FE2 homogenization framework [3] for composites with particle reinforcements at finite strains including viscoelasticity is presented. Also, proper finite element formulations have been developed in the two scales using a reduced mixed formulation in order to eliminate the possible volumetric locking in PMCs. The Hill–Mandel condition is employed for the derivation of energetically consistent transition conditions between the micro- and macro- scale. The developed model was implemented in a finite element package Abaqus for simulations of particulate PMCs. Also, different example problems and benchmark problems are presented for demonstrating the accuracy and the reliability of the here developed formulation.

Reference

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