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SIMULATION OF MAGNETIC SHIELDING BY A FERROFLUID LAYER WITH NON-UNIFORMLY DISTRIBUTED NANOPARTICLES

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An infinite cylindrical shield, made of a thick ferrofluid layer, in externally applied uniform magnetic fields is numerically investigated. The research, originated in [1, 2] for uniformly distributed feroparticles, is continued by taking into account the diffusion process, leading to a non-uniform particle redistribution in the ferrofluid.

The mathematical model consists of a nonlinear transmission problem of magnetostatics coupled with the mass-transfer equation for the ferroparticles. The permeability of the ferrofluid is dependent on the magnetic-field strength and the particle concentration. The mass transfer equation for the nanoparticles in ferrofluids is derived in [3], taking into account interactions between particles in magnetic fields. Due to no particle flux over the ferrofluid boundary, the mass transfer equation in a static limit is reformulated as an algebraic equation, which is dependent on the magnetic-field strength and the particle concentration.

The computational process is organized in the form of an iterative algorithm, where the magnetostatics subproblem for the known concentration and the concentration subproblem for the known potential are solved independently of each other at each iteration. A coupled method of finite differences and boundary elements, developed in [1,2], is applied to solve the magnetostatics subproblem. The concentration subproblem, described as a system of nonlinear algebraic equations, is solved by the Newton method. The unknown concentration values are taken at the middle points of the mesh lines for the mesh, used in the finite-difference computations.

From the results of simulations we got that the diffusion of particles has negligible influence to the shielding properties at weak and strong intensities of the applied magnetic field when comparing with the results of computations for a uniform particle distribution. But at moderate intensities of the applied field a significant equilibrium redistribution of ferroparticles inside the ferrofluid layer leads to an increase of the shielding effectiveness factor up to 10%.

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