

NUMERICAL MODELLING OF MAGNETIC FIELD SHIELDING BY A FERROFLUID LAYER

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The present research is devoted to studying shielding properties of cylindrical thick-walled ferrofluid layers protecting against uniform magnetic fields.

We consider an infinite cylinder, covered by a ferrofluid layer. The ferrofluid layer decreases an intensity of the externally applied uniform magnetic field, transmitted into the interior of the cylinder. The shielding effectiveness of the ferrofluid layer depends on the ferrofluid material properties and on the layer thickness. Different magnetisation laws are taken into consideration to model weakly-concentrated, moderately-concentrated and highly-concentrated ferrofluids.

The mathematical model is given by a nonlinear transmission problem of magnetostatics for three media: two nonmagnetic media inside and outside of the cylinder and a magnetic medium of the ferrofluid between two nonmagnetic ones. Two linear subproblems for the magnetic potential in the nonmagnetic media are described by the Laplace equations, whereas the nonlinear subproblem is formulated in the ferrofluid layer. The nonlinearity is treated in different forms resulting in three mathematical models, denoted as the model 1, 2 and 3 for weakly-, moderately- and highly-concentrated ferrofluids, respectively.

A coupled method of boundary elements and finite differences is applied to solve the magnetostatics problem. Two linear subproblems are discretised by the boundary element method. The nonlinear subproblem is approximated by the finite-difference approach with the second order on a uniform mesh. The problem is treated as a two-dimensional one in the polar coordinate system. The computational process is organized in an iterative manner, where three subproblems are solved consequently at every iteration.

The numerical computations predict an efficiency of the ferrofluid shield in weak magnetic fields with intensities of $\leq 10^2$ A/m, whereas the concentration of ferroparticles could be considered as a way to control the field intensity, shielded into the interior of the cylinder. With respect to the models 1–3, one can conclude that the magnetodipole interparticle interactions have significant influence in moderate applied fields ($10^2 < H_0 < 10^6$ A/m), and that the model 2 suits the best for the mathematical modelling of the problem under study. The first numerical results for the model 1 are published in [1].

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References

1. Polevikov V.K., Erofeenko B.T. Numerical modeling of the interaction of a magnetic field with a cylindrical magnetic-fluid layer. *Informatika*. No 2 (2017), pp. 5–13. (in Russian).