Programing simulation of high-gradient magnetic separation process based on cylinder-ball model of separator

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High gradient magnetic separation (HGMS) is one of the methods for separating fractions of magnetic or weakly magnetic particles from a nonmagnetic medium that has been widely used for over 50 years in processes of cleaning of solutions and mixtures as well as sewage treatment water from bacteria and other solid particles by using magnetic filters [1].

A lot various ferromagnetic matrices are known today. One of the most promising is a matrix of ferromagnetic steel nettings with electroprecipitated nickel dendrites on it. Model from current work tries to simulate magnetic properties of ferromagnetic matrices like that [2].

The purpose of this work is to simulate the behavior of magnetically targeted bioobjects and microparticles in a non-uniform magnetic field created by a ferromagnetic cylinder and a ball located on its surface, to determine the shape of its capture area, and also studying the influence of system parameters on the shape and size of the capture zone.

According to the work a model of dynamics of effectively paramagnetic particles under the influence of the scattering magnetic field created by a "cylinder-ball" system, which is a compound element of many constructions for HGMS, was developed. Also, a Python program was written based on this model to calculate numerically the shape of the capture area.

The following charts (Fig. 1) represent the dependence of capture area characteristic sizes on effective magnetic susceptibility of particles, their size and external magnetic field strength based on the computer modelling at such physical parameters: magnetization of a steel cylinder – 1687 Gs; magnetization of a nickel ball – 485 Gs; speed of liquid motion – 0.013 m/s; cylinder diameter – 250 μm; ball radius – 200 μm; magnetic field strength – 3500-7000 Oe; effective magnetic susceptibility of particles – 10^{-2}-10^{-7}; capturing particles sizes – 1-10 μm.

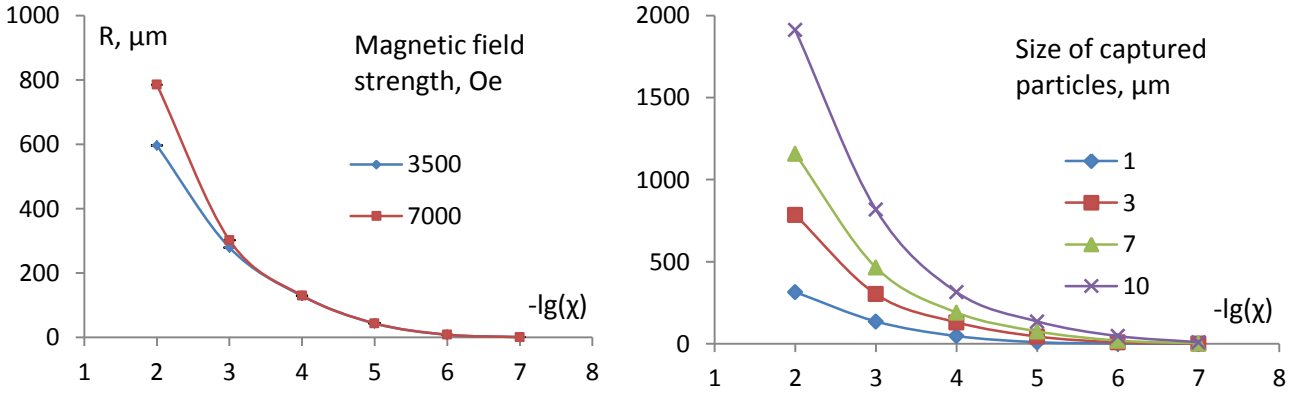

Figure 1. Dependence of the size of capturing area (R, μm) on the effective magnetic susceptibility of particles (-lg(χ)) and the strength of an external magnetic field (A) or sizes of capturing particles (μm) (B)

[1] Gerber, R., and R. R. Birss, High Gradient Magnetic Separation, Research Studies Press, London (1983);

[2] S. V. Gorobets, N. A. Mikhailenko "High-Gradient Ferromagnetic Matrices for Purification of Wastewaters by the Method of Magnitoelectrolysis" Journal of Wat. Chem. and Tech., (2014).