

CAPTURE OF MAGNETIC NANOPARTICLES ON ORDERED MAGNETIZABLE ARRAYS: A PARAMETRIC STUDY

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The present work is focused on experimental study of magnetic separation of magnetic nanoparticles of a size range of 20-100 nm on ordered arrays of nickel micro-pillars when a dilute suspension of nanoparticles (ferrofluid) flows through a flat narrow channel with micro-pillars spanning the channel width and magnetized by an external magnetic field oriented at different angles with respect to the main flow. In a typical experiment, a part of suspended nanoparticles is captured by micro-pillars forming deposits whose size and shape depend on the flow speed, magnetic field intensity, field orientation, etc., while the rest of the particles escape from the micro-pillar array if the applied magnetic field is not strong enough. On the contrary, a relatively strong magnetic field induces a phase separation of nanoparticles manifested by appearance of bulk needle-like aggregates extended along the field. Such particle aggregation enhances significantly the efficiency of particle capture described by the steady-state volume V of deposits and the parameter $\Lambda = \ln(\phi_{in}/\phi_{out})$, appearing in the filtration equation, where ϕ_{in} and ϕ_{out} are particle concentrations at the channel inlet and outlet, respectively. The effects of different dimensionless parameters governing the physics of nanoparticle capture (Mason number, dipolar coupling parameter, particle concentration, angle between the field and the flow, geometry – square or hexagonal arrays) are studied in details and the optimal set of parameters ensuring the maximum capture efficiency is found. A theoretical model based on the particle trajectory analysis is developed and confirms the main experimental findings on strongly decreasing capture efficiency as function of Mason number and dipolar coupling parameter.