The magnetic force acting on a cluster of magnetic nanoparticles, $F_{mag} = V_x \cdot M_{sat} \cdot {\mu_0}^{-1} \cdot \nabla B_x$, is balanced by the drag force, $F_{drag} = 3\pi \cdot \mu \cdot d_{cell} \cdot v$, and therefore $F_{mag} = F_{drag}$ (Tseng et al., 2009). By solving this equation we obtain the estimated volume of the MNPs cluster per cell, and the number of MNPs per cell.

Detailed calculation:

$$\mathbf{F_{drag} = 3\pi \cdot \mu \cdot d_{cell} \cdot v}$$

Medium viscosity $\mu = 7.3 \cdot 10^{-4}$ pa · s

Cell diameter $d = 8 \cdot 10^{-6}$ m

Cell velocity $v = 10\ \mu m/min = 1.7 \cdot 10^{-7}$ m/s

↓

The drag force: $F_{drag} \cong 9 \cdot 10^{-15}$ N

$$\mathbf{F_{mag} = V_x \cdot M_{sat} \cdot {\mu_0}^{-1} \cdot \nabla B_x}$$

Saturation magnetization of the NPs: $M_{sat} = 60\ emu/g = 312\ emu/cm^3$

Density of an iron oxide NP: $\rho = 5.2\ ^{g}/_{cm^3}$

In SI units ($1\ emu/cm^3 = 10^3\ A/m$) [a] : $M_{sat} \cdot {\mu_0}^{-1} \cong 3 \cdot 10^5\ A/m$

The magnetic gradient at x=2 cm [b]: $\nabla B_{x=2} \cong 3\ T/m$

Estimation of the volume of the NPs cluster: $V_x = ?$

⇓

$$9 \cdot 10^{-15} = V \cdot 3 \cdot 10^5 \cdot 3$$

Volume of the MNPs cluster: $V = 1 \cdot 10^{-20}\ m^3$

Volume of a single MNP: $\frac{4}{3} \cdot \pi \cdot (7.5 \cdot 10^{-9})^3 \cong 10^{-24}\ m^3$

⇓

Number of MNPs per cell $\cong$ 10,000

Notes

a. Taking into account that μ_0 is dimensionless and equal to 1 in cgs system.
b. According to measurements.