TECNICHE DI OMOGENEIZZAZIONE
IN MATERIALI MAGNETICI NON-OMOGENEI.

In the paper [JMMM05], [IEEETM05] and [LILLE06] the analysis of the electromagnetic field is developed on a section of the magnetic material (2D bounded domain S in $\mathbf{R^2}$), with a coordinate system denoted by $s = (x_1, x_2)$. A known time periodic magnetic flux Φ is imposed along the direction normal to the domain (unit vector e_3). The electromagnetic field problem is formulated in terms of electric vector potential $\mathbf{T} = (0, 0, T(t, s))$, defined by $\mathbf{J} = \mathrm{curl}\mathbf{T}$, where $\mathbf{J} = (J_1(t, s), J_2(t, s), 0)$ is the current density and t the time variable. Under time periodic contitions, the governing equation can be written in the harmonic domain, expressing the unknowns as phasors:

$$\begin{cases} \mathrm{i}\omega\mu(\underline{T} - M(\underline{T})) - div\left(\frac{1}{\sigma^*}\nabla\underline{T}\right) = -\mathrm{i}\omega\frac{\mu}{m}\underline{\Phi} & \text{in } S, \\ \underline{T}(s) = 0 & \text{on } \partial S, \end{cases}$$

where ω is the angular frequency and rmi the imaginary unit; $\mu = \mu(s)$ is the magnetic permeability and $\sigma^* = \sigma(s)+\mathrm{i}\omega\varepsilon(s)$ is the complex conductivity, with σ the electrical conductivity and ε the dielectric constant. $M(\underline{T})$ denotes the weighted average:

$$M(\underline{T}) = \frac{1}{m}\int_S \mu\underline{T} \quad \mathrm{d}s.$$

Assuming that σ^* and μ are space periodic, with period $Y =]0, 1[\times]0, 1[$, the following η-periodic functions are defined

$$\sigma^*_\eta(s) = \sigma^*(s/\eta), \qquad \mu_\eta(s) = \mu(s/\eta).$$

In the framework of homogenization theory, the asymptotic behavior of $\underline{T_\eta}$ as $\eta \to 0$, in the Hilbert space $H = H^1_0(S; \mathbf{C})$, is studied in order to solve the problem:

$$\begin{cases} \mathrm{i}\omega\mu_\eta(\underline{T_\eta} - M_\eta(\underline{T_\eta})) - div\left(\frac{1}{\sigma^*_\eta}\nabla\underline{T_\eta}\right) = -\mathrm{i}\omega\frac{\mu_\eta}{m_\eta}\underline{\Phi} & \text{in } S, \\ \underline{T_\eta}(s) = 0 & \text{on } \partial S, \end{cases}$$

with

$$M_\eta(\underline{T_\eta}) = \frac{1}{m_\eta}\int_S \mu_\eta\underline{T_\eta} \quad \mathrm{d}s \quad \text{and} \quad m_\eta = \int_S \mu_\eta \quad \mathrm{d}s.$$

The influence of different geometrical and constitutive parameters and the merits and limits of the method are discussed in the paper [JMMM05]. In another work [IEEETM05] the applications are considered to strip-wound amorphous cores which are commonly employed in devices working in the medium frequency range. The role of the shape and dimensions of the inclusions dispersed in a dielectric matrix is analyzed in the paper [LILLE06] with reference to the effective electromagnetic properties.