

Microstructure-based modelling of complex permeability spectra of polycrystalline ferrites

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Polycrystalline ferrites (PF) in a capacity of soft magnetic materials are of age and as such now are finding use in countless applications, especially in high frequency ones. Even so there still are unsolved problems. One particular but rather intricate problem is the presentation of complex permeability $\hat{\mu}_r(f) = \mu'(f) - j\mu''(f)$ (versus frequency f in typical, large amplitude dispersion range with $\mu'(f)$ and $\mu''(f)$ as the dispersion (DCp) and the absorption (ACp) components correspondingly). Typical problems can be seen even graphically: experimental curves of $\hat{\mu}_r(f)$ – magnetic spectra (MS) may exhibit often specific features of resonance and relaxation both together; in addition to this MS clearly depend on microstructure of PF. Based on this the semi-empirical approach is offered.

The main supposition behind the approach is the concept that observable, integral

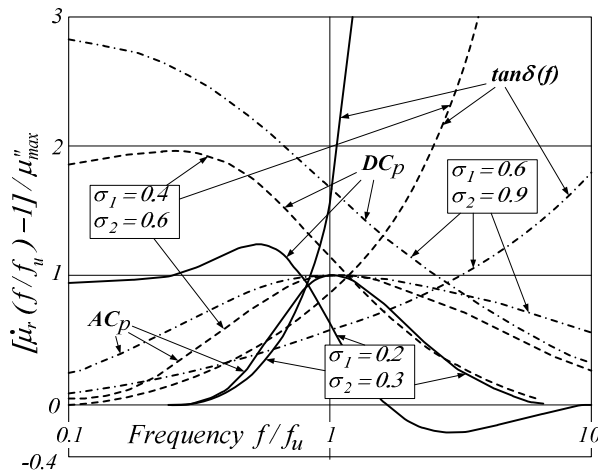


Figure 1: Normalized MS and loss tangents modelled by the account of microstructure.

size D_a (the relationships were deduced from analysis of the data from large body of samples). Assuming that D is log-normally distributed (with σ_D as the standard deviation of $\log D$), that magnetization in elementary volumes comes from oscillating domain walls, after proper statistical averaging it is possible to obtain ACp of MS against f :

$$\mu''(f) = \mu''_{\max} \exp[-(\log f - \log f_u)^2 / 2\sigma^2] \quad (1)$$

where μ''_{\max} and f_u are characterizing the absorption maximum of $\mu''(f)$; $\sigma = 2\sigma_D$. Eq.1 allows properly presenting symmetrical (along $\log f$ -axis) MS of PF that is typical only for high quality microstructure (as a rule of laboratory production). The majority of PF nevertheless have asymmetrical MS (due to intragrain defects). These MS as well are possible to cover by Eq.1, using instead of the one value for σ the twos: σ_1 for $f \leq f_u$ and σ_2 for $f \geq f_u$. This modification allows to represent all typical features of experimental MS (Fig.1; DCp of MS were calculated by the use of Kramers-Kronig relations; loss tangent $\tan \delta(f) = \mu''(f) / \mu'(f)$).

magnetic characteristics of PF sample as such appears in the process of natural averaging the parameters of elementary volume of the sample by the density functions relating from the grain size distribution. As an elementary volume (having definite magnetic parameters) is assumed the one, formed by polycrystal grain having the corresponding current grain size D . The parameters of elementary volumes versus D is expected to be in similar relationships as the analogous ones for real samples in relation to their average grain