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Effect of Particles Size on Magnetic Performance of Dielectromagnetics

Dominika Gaworska[1,a], Simon N.B. Hodgson[2,b], Jarosław Koniarek[1,c], and Bogumil Weglinski[1,d]

[1]Wroclaw University of Technology, Institute of Electrical Machines, Drives and Metrology, Wybrzeze Wyspianskiego 27, 50-370 Wroclaw, Poland
[2]Loughborough University, Institute of Polymer Technology and Materials Engineering (IPTME), Loughborough, Leicestershire, UK, LE11 3RS
[a]dominika.gaworska@pwr.wroc.pl, [b]S.N.B.Hodgson@lboro.ac.uk,
[c]jaroslaw.koniarek@pwr.wroc.pl, [d]Bogumil.Weglinski@pwr.wroc.pl

Abstract

In the paper, the influence of different particle size D: D>125µm, D<50µm and between on magnetic properties of a standardized dielectromagnetic is presented. The tests were taken at frequencies of between 50Hz, and 500Hz. Presented in the paper results provide important materials property data to allow the selection of the most appropriate dielectromagnetic particle size for different applications.

Keywords: dielectromagnetics, particle size, magnetic properties, hysteresis and eddy current loss

The research was carried out on specimens made of pure iron powder (designation "Fe") and of dielectromagnetic powders: iron powder with a 0.8% addition of dielectric ("DM-A") and iron powder with a 0.2% addition of resin and 0.53% addition of lubricant ("DM-F"). Referential pure iron powder samples were manufactured to observe the influence of dielectric addition on the behaviour of magnetic properties as they change with particle size.

For each DM, the following particle fractions were used for research (D-size of powders particles): D>125µm, 90µm>D>71µm, 71µm>D>50µm, 50µm>D. Magnetic properties have been measured by a computerized measurement system MAG-TD200 at frequencies: 50 and 500Hz.

For all the examined powders, the increase of particle size causes increase of magnetic induction (Fig. 1) and of maximum magnetic permeability (Fig. 2). The better properties of powders with large particles (D>125µm) result from the way in which magnetizing process is conducted.

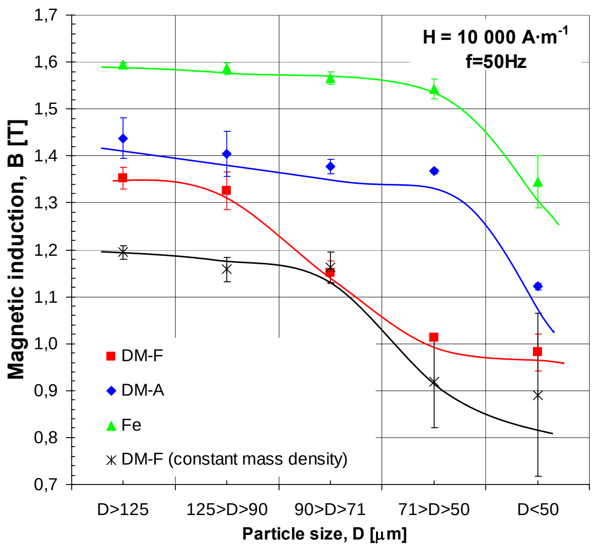

Fig. 1. Magnetic induction for H=10 000 A·m^{-1} at f = 50Hz.

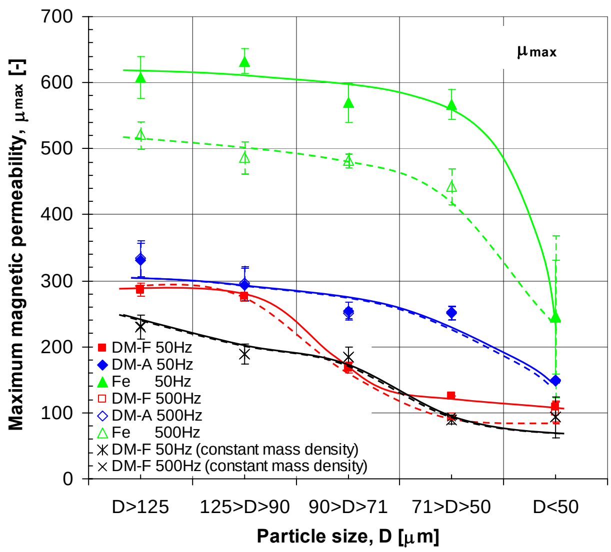

Fig. 2. Maximum magnetic permeability at f = 50 Hz and 500Hz.

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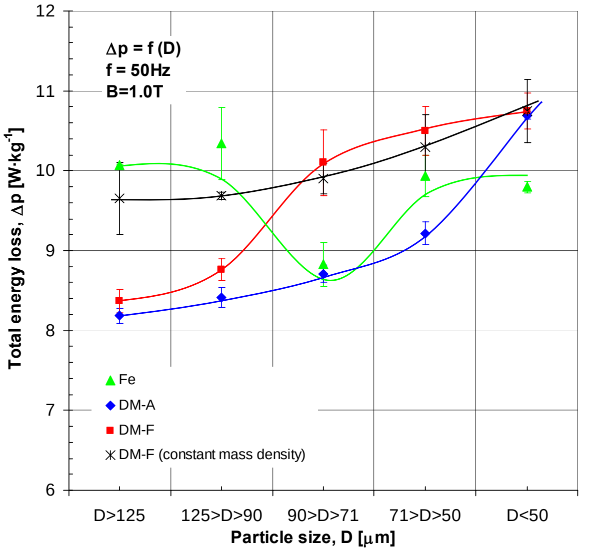

Fig. 3. Total energy loss of tested powders at B=1.0T and f=50Hz.

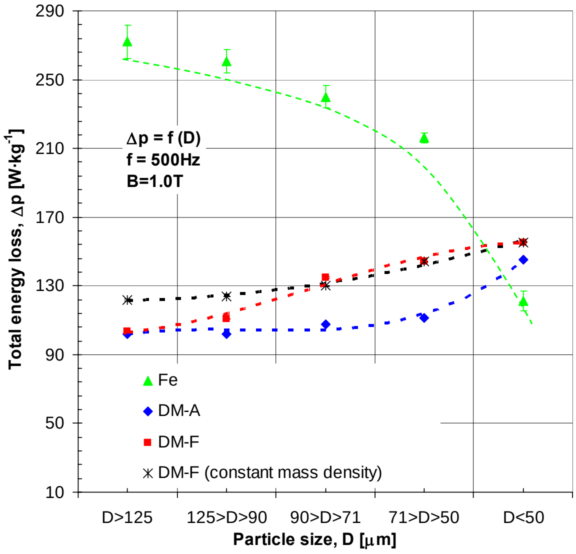

Fig. 4. Total energy loss of tested powders at B=1.0T and f=500Hz.

The decrease of maximum magnetic permeability of "Fe" samples at higher frequencies results from high total energy loss. The lack of dielectric isolation between ferromagnetic particles leads to generating high eddy current loss. Due to higher eddy current loss, the samples made of iron powder consisting of coarse particles (D>90μm) are characterized by higher total energy loss than those made of powders with particle size 90μm<D<71μm. However, total energy loss of samples with smaller particles increases, but it results most probably from hysteresis loss increase and not eddy current one (Fig. 3 and 4).

At 50Hz (Fig.3), minimum total energy loss of iron powders ("Fe") is obtained for particle size up to 90>D>71μm. The increase of total energy loss for fine particles comes from higher hysteresis. At higher frequency, eddy current dominates and total energy loss of iron powder increases along with increase of particle size in the whole range of sizes (Fig. 4)

In case of DMs with particles isolated from each other by the dielectric, the eddy current loss is limited and hysteresis loss is the main share of DMs' total energy loss. High hysteresis loss of DMs results mainly from the presence of non-ferromagnetic phase between iron particles.

As far as DM with the same mass density but made of powders with different particles size is considered, it is worth noticing that similar behaviour was observed. This could indicate that increase of hysteresis loss for samples made of low particle size results mainly from hindered magnetization process of particles with small size. This is similar to what was observed in case of iron powders. Because total energy loss of DMs with the largest particles is the lowest of all, even at high frequency due to sufficient limit of eddy currents and low hysteresis loss, one can state that it is purposeful to make the DM powders with dominating coarse fraction. Of course, to limit eddy current, good isolation between magnetic particles must be ensured, and the size of a single particle should be determined by working frequency of DM magnetic core and depth of magnetic flux penetrating a single particle.

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