Correlation Between Permeability, Losses and Compact Formation in a NiZn Ferrite

O. Causa and A. González Arias
Depto. Física Aplicada,, Facultad de Física, Universidad de La Rabana
Ciudad de La Habana 10400, Cuba

Received January 20, **1993**

The correlation between initial permeability μ_i, loss factor $tan\delta$ and powder compaction piessure in a ferrite of nominal coniposition $Ni_{0.33}Zn_{0.64}Fe_{2.06}O_{4+\alpha}$ synthesized by ceramic methods is shown, for two groups of samples with different amounts of binder added. The least pressure necessary to obtain tlie best magnetic properties in botli cases was about **3** ton/cm^2. However, this behavior is not refiected in any singularity of tlie green density curves as should be expected when compasing with other inaterials, not allowing tlie use of these curves alone as a measure of coinpact quality before firing in NiZn ferrites.

I. Introduction

The microstructure parameters of polycrystalline magnetic materials usually have a decisive infiuence on magnetic properties. A given chemical composition may originate very different properties in dependence of tlie conditicns at the grain boundaries, the grain size and pore distiibutions and the preseiice or not of microinhomogeneities. The microstructure is controlled by a great nuinber of parameters of the synthesis procedure, such as tlie thermal treatments, compact formation and, when solid reaction synthesis is carried out, morphology and grain distribution of the powdered raw rnaterials and milling[1-4].

In tlie case of ferrites obtanied by sintering the previously reacted and compacted powdered material, the parameters related to the compactation process have a strong influence on microstructure and on magnetic properties. Exsmples are the differences obtained when the compactat on is carried out by isostatic pressing or by hot-pressing instead of the conventional die-pressing. Die-pressing is the most important one for practical purposes, due to its relative simplicity[2].

One of the parameters to take into account when the compact is formed is the so called "green" density. In many inaterials it usually increases almost linearly with the compaction pressure to a given value, where a change of slope takes place. This is attributed to fractures or plastic deformation in the grains which appears when the elastic limit of the powdered material is exceeded. In the case of ceramic materials, another parameter which must be taken into account is the amount of binder added, essential to obtain a green compact stiff enougli so as to keep its shape in further manipulations[5,6]. The aim of the present research was to study tlie correlation between the green density and tlie best magnetic properties of tlie NiZn ferrite samples.

II. Experimental

Samples of NiZn ferrite witli composition $Ni_{0.33}Zn_{0.64}Fe_{2.06}O_{4+\alpha}$ were prepared using conventional ceramic techniques from analytical reagents, heating the powders at 900 °C after mixing wet in a 50% ethanol aqueous solution for 1 hour in a vertical steel ball mill. The calcined powders were wet milled again for tlie same time, and compacts with good stiffeness were obtained by die-pressing in tlie form of square section toroids, witli external and internal diameter of **23** and 11 mm respectively, adding polyvinyl alcohol dissolved in water as binder to a extent of 1.5 dry wt% (A samples) and 2% (B samples). Before coinpacting, tlie mixed powders were forced througli a sieve with 1 mm^2 openings. The toroids were sintered at a maximum temperature of 1200 °C (1 hour) witli a rate of heating and cooling of 300 °C/h from room temperature[7]. The green and fired densities of tlie compacts were measured in air, as well as the initial relative permeability μ_i and tlie loss factor $\tan\delta$ of tlie fired samples, using a Tesla BM-560 Q-meter.

III. Results and Discussion

The variation of μ_i as a function of the applied compacting pressure appears in Fig. 1. In both cases tlie permeability increased almost linearly with the applied pressure up to about tlie same value of 3.5 toii/cm^2, where it tended to stabilize. Tliis behaviour is reflected in the fired density of tlie two groups of samples, where a slight stabilization or change of slope is reached at about 3-4 ton/cm^2 (see Fig. 2). Losses also sliow a minimum in tlie saine range of pressures; liowever. tlie surpassing of 3.5 ton/cm^2 was deleterious for tlie B samples (Fig. **3**). In all figures tlie drawn curves are tlie result of adjustiiig the experimental points to 2nd and 3rd degree polynomials by numerical methods.

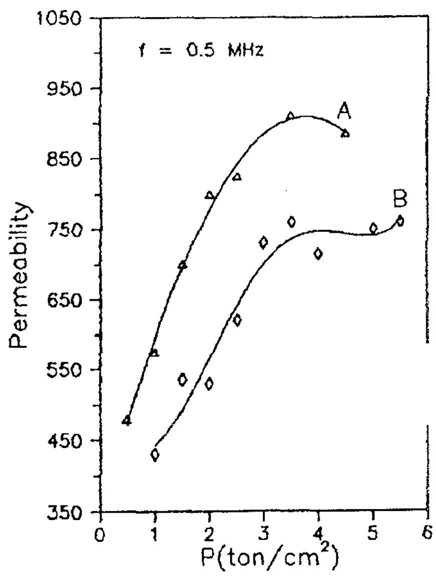

Figure 1: Relative permeability μ_i vs applied cornpaction pressure; **A)** 1.5 wt%; **B)** 2 wt% polyvinyl.

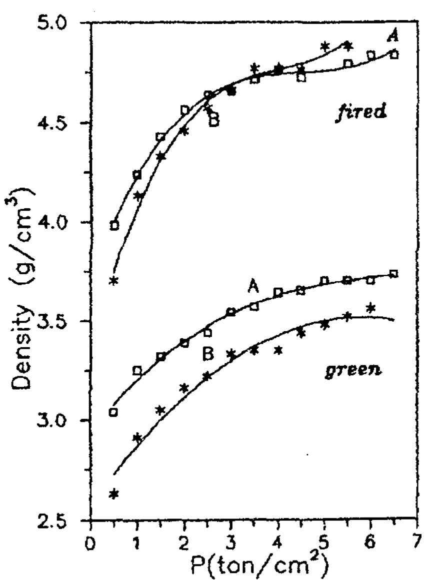

Figure 2: Green and fired densities in $Ni_{0.33}Zn_{0.64}Fe_{2.06}O_{4+\alpha}$ samples as a function of tlie applied compaction pressure. **A)** 1.5 wt%; **B)** 2 wt% polyvinyl.

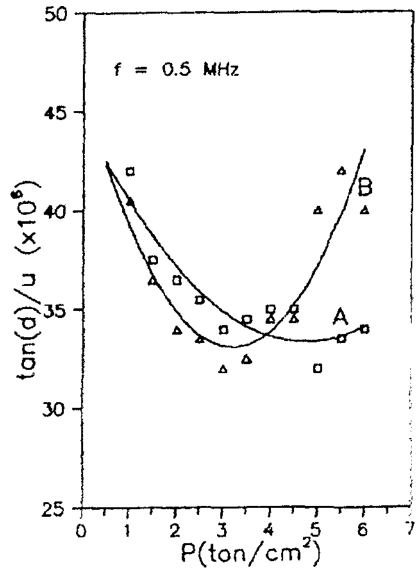

Figure **3**: $\tan\delta/\mu$ for tlie samples of Figure 2.

The difference in perrneability for A and B samples in Fig. 1 suggests an appreciable dependence of μ_i on the amount of added polyvinyl in tlie range analyzed. This difference is also reflected in tlie green density curves of Fig. 2; however, tlie non-controlled humidity of tlie mixed powders and tlie fact tliat tlie difference in permeability is not reílected in tlie íired density curves did not allow us to attribute tlie observed beliavior to tlie different amounts of polyvinyl in each group of samples; i.e., differences iii tlie humidity of tlie samples and minor changes in tlie sintering temperatures could originate the same effect.

The least pressure necessary to obtain tlie hest magnetic properties in both cases was about 3 ton/cm^2. However, this value was not refiected in aiiy singularity of the green density curves, not allowing tlie use of these curves alone as a measure of coinpact quality before firing.

References

1. J. Smitli and II. P. J. Wijn, *Ferritas* (Biblioteca Técnica Philips, Madrid, 1965).
2. D. J. Craik, *Magnetic Oxides* (Wiley, New York, 1975).
3. P. I. Slick, *Ferromagnetic Materials*, (North Holland, Amsterdam, 1980) Vol.2.
4. R. S. Tebble and D. J. Craik, *Magnetic Materials* (Wiley-Interscience, New York, 1969).
5. J. S. Reed and R. B. Runk, *Dry Pressing* in *Treatise* on *Materials* Science *and Technology,* Edited by F. F. Y. Yang (Academic, New York, 1976) Vol. 9.

6. O. J. Whittemore, *Particle Compaction* in *Ceramic Processing Before Firing*, Edited *hy* G. Y. Onoda and L. L. Hench (Wiley, New York 1978) p. **343.**

7. I. V. Guerasimenko and A. González Arias, Phys. Stat. Sol. (a) 88, K159 (1985); Rev. Latinam Met. y Mat. 5 (1985).