Soft magnetic composites with enhanced permeability and low core losses prepared by mixing of Somaloy with Fe-P particles

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In this work, we have investigated the effect of intermixing of uncoated iron-phosphorous particles (PASC60) with Somaloy soft magnetic composite (SMC) powder on the magnetic properties of ring-shaped compacted samples. The samples were compacted to similar densities and then heat-treated in steam at 500°C for 20 minutes, allowing the formation of a protective oxidation coating. DC magnetization curves and AC magnetic properties up to 2 kHz were analysed. For the samples with the smaller content of PASC particles, we have observed improved DC permeability combined with low AC losses, which could be beneficial for applications of such prepared SMCs at low and medium frequencies. Moreover, intermixing of uncoated PASC particles could help to lower production costs of the SMCs manufacturing process.

Keywords: soft magnetic composites; hybrid composites; powder cores; permeability

1. Introduction

Conventional soft magnetic composites (SMCs) are produced by compacting soft ferromagnetic particles coated with a thin layer of insulation [1]. The easy preparation of miniaturized components with complex morphologies is one of the main advantages of SMCs over Fe-Si steel sheets [2]. Moreover, their high electrical resistivity limits eddy currents that are responsible for energy dissipation at higher operational frequencies. A disadvantage of the SMCs is their relatively high price and low permeability caused by the presence of non-magnetic part. The modifying of the magnetic properties of classic SMCs is possible by incorporating a secondary soft magnetic powder [3]. In this work, we have studied the ring-shaped samples prepared by compacting homogenized mixtures of two different powders - coated iron (Somaloy) and less-expensive uncoated Fe-P (PASC).

2. Results and discussion

The structure of compacted samples was studied using an optical microscope equipped with a Laser-Induced Breakdown Spectroscopy (LIBS) analyser, as shown in Figure 1.

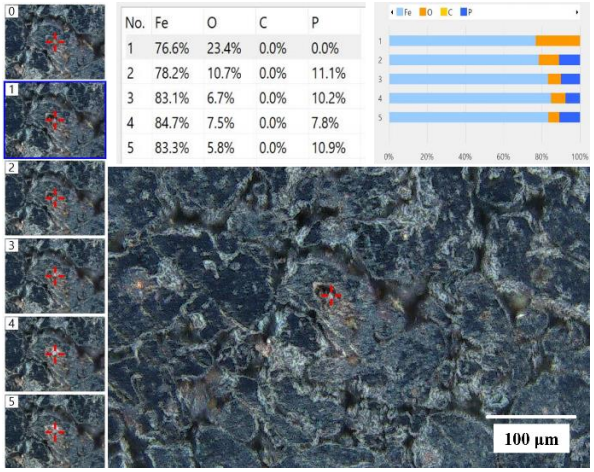

Figure 1: Multilayer LIBS analysis of compacted powder heat-treated in steam showing the distribution of iron, oxygen, phosphorous and carbon.

DC magnetization curves and hysteresis loops up to 2 kHz were measured by REMAGRAPH® - REMACOMP® combination C-705 (MAGNET-PHYSIK, Germany). In Figure 2, changes in permeability can be observed depending on the amount of intermixed Fe-P particles. Heat treatment in steam has been confirmed as an effective method for improving DC permeability while also forming a protective oxide layer on the SMC material.

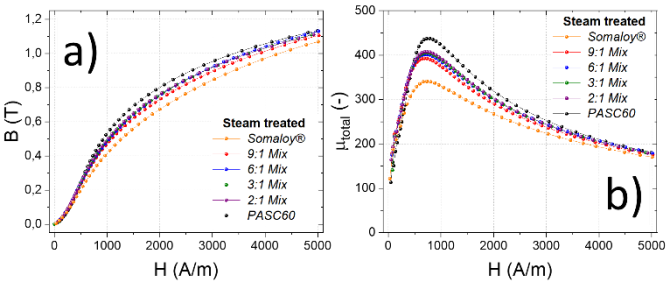

Figure 2: DC magnetization curves a) and field dependence of the total permeability b) of the SMC samples

The total DC permeability of the compacts made from intermixed powders markedly increases compared to the original Somaloy compact. Coercivity and total losses of samples were also analysed. The results indicate that intermixing Somaloy with up to 15% uncoated PASC powder allows the SMC material to maintain very low AC losses across the entire investigated frequency range.

References

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