Magnetic behaviour of $Cu_{0.8}Zn_{0.2}Fe_2O_4$-polystyrene composites

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The current research activities are aimed at selecting a soft magnetic material and preparing its composites for automotive applications. Soft magnetic composites consisting of $Cu_{0.8}Zn_{0.2}Fe_2O_4$ powder dispersed in polystyrene with different polymer-to-ferrite ratios were prepared. The coercivity and remanence of pure $Cu_{0.8}Zn_{0.2}Fe_2O_4$ were measured 96.7 Oe and 11 emu/g, respectively. Polystyrene is not negatively affecting the magnetic properties of $Cu_{0.8}Zn_{0.2}Fe_2O_4$ as a polymer matrix. Normalized remanence of composites is approaching the remanence of pure powder following a linear behaviour. There is an increase in coercivity by almost 50 % for polystyrene-$Cu_{0.8}Zn_{0.2}Fe_2O_4$ soft magnetic composites.

1. Introduction

Soft magnetic materials are used in applications like electric motors, sensors, and transformers. The global demand for cost-effective and energy-efficient soft magnetic materials has driven research into improving their properties [1]. The advanced transversal flux motors require complex three-dimensional magnetizing directions, making electrical steels impractical as they are limited to two-dimensional magnetic flux [2]. Moreover, electrical steels have high eddy current losses at frequencies above 500 Hz, leading to low efficiency. Hence, alternatives are needed for higher-frequency applications [3]. Soft magnetic composites (SMCs) consist of soft magnetic powder particles embedded in polymer matrices and offer benefits such as reduced eddy current losses, low core losses at elevated frequencies, and isotropic physical properties [1-4]. They are particularly effective in the frequency range of 400 Hz to several kHz, bridging the gap between laminated steel cores and ferrite cores [3].

In the current research, polystyrene was used as matrix for $Cu_{0.8}Zn_{0.2}Fe_2O_4$ powders prepared with a self-combustion method, aiming to investigate the effects of ferrite and polymer content on the electromagnetic properties of these soft magnetic composites (SMCs).

2. Results and discussion

The magnetic composites of polystyrene-$Cu_{0.8}Zn_{0.2}Fe_2O_4$ were prepared with different particle loadings. **Fig. 1** presents M versus H loops at room temperature. These loops are normalized to the respective weight concentrations of particles, allowing for an accurate comparison of magnetic properties regardless of varying concentrations. **Fig. 2 (a)** shows that these composites have up to 50 % increased coercivities compared to the pure $Cu_{0.8}Zn_{0.2}Fe_2O_4$ composition alone, which has a coercivity of 96.7 Oe. This is ascribed to the physical separation between particles that increases in the composite and consequently diminishes their dipolar coupling, leading to a more independent behaviour of each nanoparticle that requires stronger external fields to reverse its magnetisation. **Fig. 2 (b)** shows that the remanence of the composites increases with the concentration of magnetic particles; the saturation follows a similar trend. The dashed straight line shows that the magnetic properties of ferrite remain unchanged and approach the behaviour of pure $Cu_{0.8}Zn_{0.2}Fe_2O_4$ powder as the concentration of ferrite increases in the composite. A detailed discussion of the soft magnetic properties of these $Cu_{0.8}Zn_{0.2}Fe_2O_4$-polystyrene composites is presented.

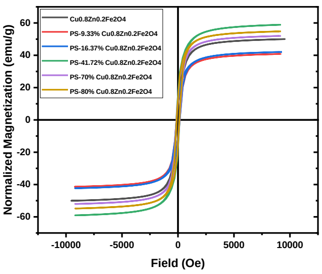

Figure 1: Hysteresis loops of samples with different $Cu_{0.8}Zn_{0.2}Fe_2O_4$ loadings.

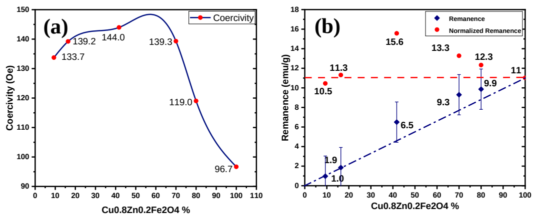

Figure 2: (a) Coercivity and (b) Remanence of composites with different $Cu_{0.8}Zn_{0.2}Fe_2O_4$ loadings.

References

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