Recent advances in additive screen printing of Fe-Co Soft Magnets

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Electric drives in high-performance applications rely on Fe-Co electric steel sheets for their exceptional magnetic properties, notably high magnetic induction and permeability. Conventional manufacturing through milling, punching, or laser cutting is costly due to high offcuts and cobalts high price on one side and the hard workability of brittle Fe-Co. Screen printing enhances feedstock powder yield and offers design freedom of stator and rotor geometries. Therefore, additive manufacturing is a cost-and resource effective approach of additive manufacturing FeCo sheet material.

Keywords: FeCo; screen printing; soft magnetic material; magnetic properties

1. Introduction

In the realm of high-performance electric drives, the demand for advanced soft magnetic components is paramount to achieve motors with superior power density. Fe-Co alloys have emerged as a critical material due to their outstanding magnetic properties, including high magnetic induction and permeability.

However, traditional manufacturing techniques such as milling, punching, and laser cutting present challenges due to the brittle nature of Fe-Co and the high cost associated with cobalt. The introduction of vanadium into the alloy composition has significantly improved ductility, facilitating processing by milling and enhancing the specific electric resistance [1]. This advancement reduces overall losses during magnetization and demagnetization processes by minimizing eddy current losses. Furthermore, screen printing technology offers a promising solution by optimizing feedstock powder yield and providing design flexibility for stator and rotor geometries [2]. Consequently, additive manufacturing emerges as a cost-effective and resource-efficient method for producing Fe-Co sheet materials, revolutionizing the fabrication of electric steel sheets for high-performance applications.

2. Results and discussion

Sheets of FeCo have been prepared through additive manufacturing, utilizing powder metallurgical techniques. Fe-Co sheets were produced by screen printing followed by a heat treatment that addressed both sintering and the adjustment of magnetic properties.

In this study, two approaches were pursued: using elementary powder mixtures and gas-atomized powders to manufacture Fe-Co sheets. The magnetic characteristics of three different samples with a thickness of approximately 250 µm are presented in Table 1: Sample A – gas atomized and Samples B and C – elementary mixtures. The coercivity is well below the benchmark of 100 A/m that a Fe-Co alloy should achieve, while a polarization of up to 2.35 T is reached. Clearly, the DC properties are comparable to conventionally prepared sheet material.

Table 1 magnetic properties (Hc, µmax and J8 k A/m) of samples A, B and C .

sample	Hc / Am-1	μ_{max}	$J^{8\ k\ A/m}$ / T
A	85.2	6295	2.19
B	50.7	8089	2.35
C	88.7	5499	2.17

In the presentation the relation between screen printing, heat treatment and magnetic properties will be discussed in detail, highlighting the advantages of the presented additive manufacturing technique for high performance applications of Fe-Co sheet material.

References

[1] Bozorth, Ferromagnetism, IEEE Press, 1978
[2] Lindemann, et al., Potential of powder metallurgical methods to fabricate Fe-6.5Si soft magnetic components, Powder Metallurgy, 2024

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