Development of innovative MnZn-NiZn bi-material ferrites using FDM additive manufacturing

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The democratization of additive manufacturing (AM) technologies began in the late 1980s with the emergence of the first 3D printers. Today, they offer solutions adapted to the challenges faced in various domains of scientific research and industry. In particular, electrical engineering can greatly benefit from the opportunities offered by fused deposition modeling (FDM) printing and can take advantage of a widening range of printable materials. This process overcomes the limitations of standard manufacturing processes using additive manufacturing by developing new bi-material ferrites. The optimization and advancement of such bi-material components could pave the way for customized magnetic parts providing new magnetic properties.

Keywords: Additive manufacturing, fused deposition modeling, ferrite, Mn-Zn, Ni-Zn

1. Introduction

In recent years, additive manufacturing (AM) of magnetic materials has been attracting growing interest. Various studies highlight the potential of additive manufacturing for electrical engineering applications that challenge conventional manufacturing processes [1]-[2]. In particular, ferrite manufacturing using metal injection molding (MIM) used to produce ferrite components. A major limitation of MIM is the mold manufacturing cost which makes the process unsuitable for prototyping or low-volume production. In this context, recent work has led to the development of the MIM-like additive manufacturing process [3] based on fused granulate fabrication (FGF) printing.

In this work, an FDM additive manufacturing process derived from MIM-like is proposed. This process overcomes the challenges inherent to FGF printing but requires a manufacture stage of powder-filled ferrite filament. The reliability of this additive ferrite manufacturing process enables the production of multi-material ferrites with complex shapes.

2. Results and discussion

This work has resulted in the development of a complete additive manufacturing process for MnZn and NiZn ferrites from the manufacture of the filament made from polymer granules and ferrite powder to the printing of the components performed with Hemera Revo XS extruders mounted on the open source 3-axis E3D Tool Changer printer. The so-called « green parts » have been subjected to debinding before being sintered under a controlled atmosphere. Finally, magnetic characterization of the finished components allowed validation of the AM process using FDM printing. Both NiZn and MnZn components have been characterized independantly on toroidal shape cores. Each core has reached comparable magnetic performances to those produced by conventional manufacturing processes in terms of magnetic permeability and losses.

(a)

(b)

Figure 1: (a) toroidal NiZn-MnZn bi-material magnetic core; (b) Side view of the printed core.

The presented process offers the possibility to print a component by using different materials. On a further stage, an innovative trial has been successfully carried out to manufacture a bi-material MnZn-NiZn component. This toroidal core, illustrated in Figure 1, is made up of 13 MnZn ferrite layers (black) and 13 NiZn layers (brown). In the full paper, the component will be sintered to validate the geometric shrinkage and characterized to analyze the magnetic performance of the co-sintering.

References

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