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INNOVATIVE 3D PRINTED SOFT MAGNETS FOR SATELLITE ELECTRIC MOTORS

Abstract

Soft magnetic materials are currently employed in a wide range of applications in electronic, computer and telecommunication industries. In electric motors, a great part of devices and structures are made up in soft magnetic materials, with the purpose of guiding the rotating magnetic field, due to their favourable magnetic permeability. Pure iron and its alloys, minerals like magnetite and maghemite, different types of ferrites, and elements like Ni and Co are traditional soft magnetic materials. The manufacturing processes of this kind of materials involve sintering phase (when dealing with powders) or casting techniques. In a conventional electric motor, laminated steel with 1-4% silicon content plays a functional role as ferromagnetic core and occupies a predominant fraction of the available total volume. The manufacturing process of electrical steel sheets is labour intensive, consisting of different stages in a row, such as casting, rolling (hot and cold) and annealing. The conductive nature of steel, moreover, decrease the efficiency of the motor, due to the presence of eddy currents that dissipate a consistent fraction of the power supplied. The constant need for lightweight structures in aerospace applications motivates recent request for innovative materials suitable to replace the existing ones, such as heavy iron based metals with magnetic bonded composites, obtaining a reduction in weight and preventing eddy current losses. Furthermore, the use of ALM technology allows to realize lighter components by means of topology optimized design. The major scope of our activity is the development of a novel soft magnet polymeric composite material, being 3D printable and space compliant. The soft magnetic composite material has been manufactured via 3D printing techniques, using a space compliant polymeric matrix PEEK (poly-ether-ether-ketone) and magnetite (Fe3O4) micro/nano particles. The composite has been characterized in terms of magnetic, mechanical and thermal properties showing promising performances and a proof of concept 3D printed part has been realized. A case study of a Brushless Direct Current (BLDC) Electric Motor containing the new 3D printed soft magnetic composite has been further investigated via Multiphysics Numerical Analysis to evaluate the performance of the material in the electromechanical device.