Additively manufactured magnetic components for passive stabilization of nanosatellites

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The passive stabilization of nanosatellites is proposed using additively manufactured magnetic components made by FeSi alloys. The model of the magnetization process, identified using a suitable set of magnetic measurements, is implemented in a finite element scheme Different shapes and sizes are simulated in order to enphasize the power losses due to hysteresis phenomena and therefore to reduce the stabilization time. Different performances are showed take into account different working temperatures.

Keywords: Additive manufacturing; magnetic hysteresis; magnetic models; magnetic measurements.

1. Introduction

The stabilisation of small classes of satellites in orbit, such as the nanosatellites, can be achieved using a passive magnetic attitude control system. This generally consists of permanent magnets and ferromagnetic bars, designed with specific shapes and sizes to optimise system performance. Many papers present numerical computations and experiments to demonstrates the attitude and performances of different setups. Different kind of alloys and different geometries of that passive elements are compared and discussed [1-3]. Starting from the study and the analysis of this literature, we propose here a different technology to product those passive components, the additive manufacturing. In particular, we present a computational tool to simulate the magnetic behaviour of the elements, when they are rotating in the earth magnetic field at certain altitude, in order to compute the energy dissipation. The computational scheme involves hysteresis phenomena, the eddy currents distribution and the demagnetizing effect. The electric and magnetic properties are identified using samples made by a laser powder bed fusion process. This technology seems to be very promising for the indicated scope due to the capability in the realization of complex geometry and the use of different alloy compositions. Moreover, one of the scope of the paper is to verify if the annealing process of the components, well recommended for other purposes, is still useful also in this application. Different working temperatures are taken into account to simulate the corresponding stabilization times.

2. Results and discussion

The figure below illustrates the energy dissipation of magnetic components, with shape and dimensions optimized for cubesat stabilization, operating along a conventional orbit at an altitude of 600 km. In this specific case, two different samples were investigated: one with an annealing process and one without. The working temperatures considered are -20 °C and +50 °C, which are the typical upper and lower limits for this class of satellites. The specific shape of the magnetic components has been selected using the analytical formulation for the computation of the demagnetizing field.

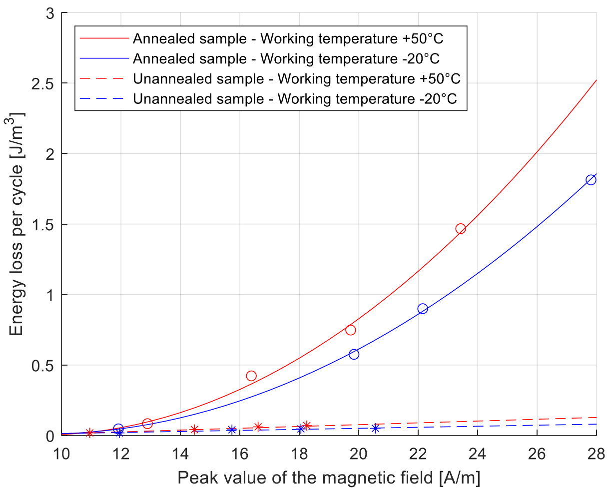

Figure 1: Comparison between the energy dissipation of passive magnetic components made by additive manufacturing, with and without annealing process, and for two different working temperatures.

The energy losses have been computed using a finite element scheme with a suitable hysteresis model based on Jiles Atherton approach. The simulations are carried out take into account the presences of several rods and their interactions. Cylindrical shapes and prolate spheroids have been investigated pointing out their best sizes for specific constraints.

References

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