Optimization of quadrupole core for homogenous magnetic field using non-oriented silicon-iron materials

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The aim of this paper is to provide a solution for obtaining a homogenous magnetic field in an area of 1 square cm (2D), 1 cm sphere diameter (3D) where a biological cell will be placed. Two different quadrupole configurations and 4 types of silicon-iron materials for the core were considered. Preliminary investigations use professional 2D and 3D analysis software, and the results will lead to the manufacturing of a core that offers the best results.

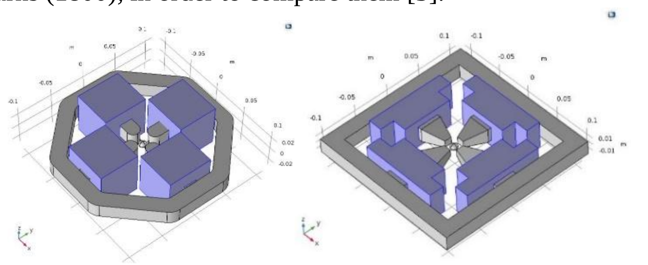
Keywords: Magnetic cores, NO steels, FEM Modelling

1. Introduction

The paper aims to provide optimal solutions for uniform magnetic field sources for biomedical investigations [1]. The realization of such a device using soft magnetic materials of the NO type will lead to interdisciplinary investigations [2]. Using specialized FEM analysis software, the aim is to identify the material and the constructive solution that offers the best results.

2. Results and discussion

Two quadrupole configurations (Q1 and Q2), presented in Fig. 1 were considered in this study They have the same geometric boundaries (22 x 22 cm) and the same number of turns (1800), in order to compare them [3].



Q1 Q2

Figure 1: Geometries of the quadrupole cores used in modelling (grey zone is the core and the blue is for the coils).

The study followed the influence of the material used in the core, to provide a homogeneity of the magnetic field of at least 98% in the area of interest (1 cm diameter) where the biological sample will be placed. Obviously, a higher magnetic induction for a wider frequency range is also desirable. The first magnetization curves for the 4 types of NO sheets considered are presented in Fig. 2 [4].

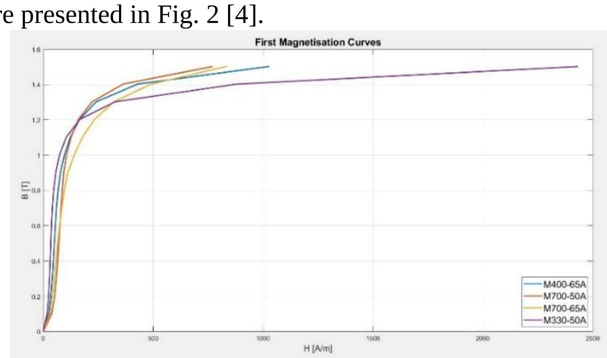
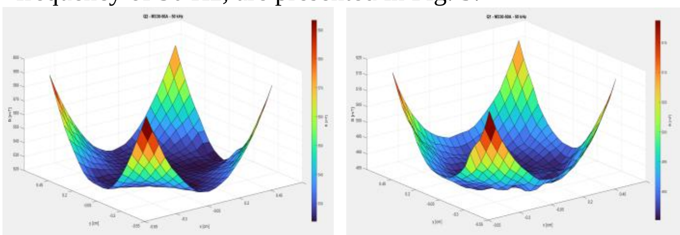


Figure 2: First magnetisation curves for the four used materials.

The comparative analysis shows the effect of the core material on the obtained level of uniform magnetic field in the bioreactor zone, at various frequencies of the supplied current (from 50 to 1000 Hz). As an example, the magnetic flux density maps for the two configurations using M330-50A sheets, at a frequency of 50 Hz, are presented in Fig. 3.



Q1 Q2

Figure 3: 3D map of the magnetic flux density for both configurations using M330-50A core materials at 50 Hz.

Comparing with the other three materials (M400-65A, M700-50A and M700-65A) it can be concluded that M300-50A offers the highest average magnetic flux density values (486 mT for Q1, respectively 526 mT for Q2) at 50 Hz, but not very high compared to the other materials. The increasing of the frequency (from 50 to 1000 Hz) leads to the reduction of the magnetic flux density with up to 4% for both configurations. However, the Q1 configuration offers an area of about 77% homogeneity (according to the previous definition) compared to 68% in the case of the Q2 configuration.

References

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