Optimization of a Rotor Shape for Spherical Actuator with Magnetically Levitating Rotor to Match Octupole Field Distribution

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Abstract

The use of a reaction sphere as an actuator used by satellite Attitude Control System was proposed over twenty years ago. In a principle this concept assumes the use of a single reaction sphere which can be accelerated in any direction instead of set of reaction wheels. Traditionally the attitude of the satellite can be changed as a result of reaction to the acceleration of the appropriate wheel. As an alternative, the reaction sphere can be accelerated in any direction by a three dimensional (3D) motor. However,originally proposed designs had poor efficiency and a complex coupling between bearing and motor functions, which lead to unusable designs. The solution discussed in this work has been proposed and patented by a CSEM company. In opposition to conventional ball bearing momentum exchange devices, in this solution the rotor levitates magnetically which results in absence of friction and increase of performance. The sphere can be accelerated in any direction by a three dimensional (3D) motor, making the three axes of the spacecraft controllable by just a single device. The proposed solution of actuator is based on an 8-pole permanent magnet rotor and 20-pole stator with electromagnets (see fig.1). In this work we are reporting results of modelling a reaction sphere using COMSOL Multiphysics®. In particular we present results of rotor shape optimisation of which aimed to get the best approximation of generated magnetic field closest to one of ideal octupole at a distance from stator coils. In the simulation model the permanent magnets were chosen as neodymium magnets. Numerical model of the reaction sphere system was prepared and solved using COMSOL Multiphysics® while mechanical structure and components were prepared in ProE system and transferred into COMSOL environment. Geometrical parameters which were optimised are shown in Figure.2.

Figures used in the abstract

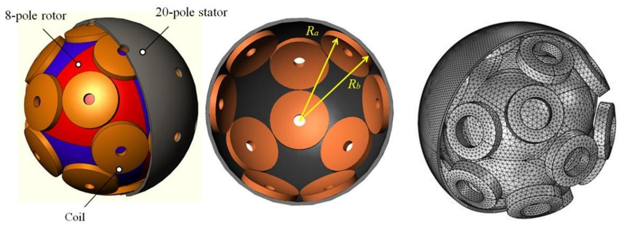

Figure 1: The structure of reaction sphere actuator with magnetically levitated rotor.

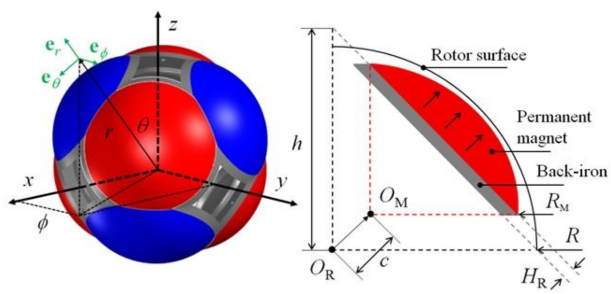

Figure 2: Geometrical parameters of the rotor which were a subject of the optimization procedure.