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磁悬浮反作用飞轮剩磁矩分析与补偿方法研究

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Research on Analysis and Compensation Method of Remnant Magnetic Moment for Magnetically Suspended Reaction Flywheel

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摘要 为对磁悬浮反作用飞轮的剩磁矩(RMM)进行分析及最小化设计,提出一种基于等效磁偶极子模型的剩磁矩计算方法。利用有限元仿真空间磁场分布,通过选取3个特征平面的磁场反推得到剩磁矩。对不同工作状态下飞轮样机剩磁矩的大小及变化范围进行了分析,并在此基础上给出了磁悬浮反作用飞轮剩磁矩优化设计方法及补偿方法。分析结果表明,通过磁轴承磁对称设计及永磁体补偿可以有效地将剩磁矩减小至一定范围内。对飞轮样机的剩磁矩实验验证了该分析方法及补偿方法的正确性。

关键词: 磁悬浮反作用飞轮 剩磁矩 有限元方法 卫星磁洁净 磁补偿 磁测试

Abstract: To analyze and minimally design the remnant magnetic moment (RMM) for a magnetically suspended reaction flywheel, a method based on the equivalent magnetic dipole model is proposed. Firstly, the space magnetic field distribution can be achieved by finite element analysis, and then through selecting the magnetic field distribution of three feature planes, the RMM can be derived. The values and range of the RMM of a prototype are investigated in different operation situations. Based on the above analysis, an optimal design and magnetic compensation method for reducing the RMM is proposed. The analytical results show that the RMM can be effectively reduced to a certain range by a magnetic symmetric design of the magnetic bearings and compensation with a permanent magnet. The experimental results of a prototype demonstrate the validity of the analysis and compensation method.

Keywords: magnetically suspended reaction flywheel remnant magnetic moment finite element method satellite magnetic cleanliness magnetic compensation magnetic test

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