ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (2)

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RESEARCH ON DESIGN AND PERFORMANCE ANALYSIS OF HIGH POWER ELECTROMECHANICAL ACTUATOR APPLIED TO SPACECRAFTS

Abstract

Actuators in aerospace applications are used to meet the spacecrafts control requirements while minimizing size, weight, and cost. The actuators performance requirements are typically specified in terms of load-velocity, frequency response and duty cycle necessary to provide spacecrafts stability and performance for the space mission. A high external load usually determines that actuators must be provided with ability of high power output for spacecrafts flight control, especially for the thrust vector control (TVC) of solid rocket engine. Electrohydraulic actuator (EHA) based on the conventional hydraulic technology is common in spacecrafts, where its high power-to-weight ratio and precise control makes it an ideal choice for use in flight trajectory control. In general, applications with bandwidths greater than about 20 Hz or control power greater than about 15 kW can be regarded as suitable for electrohydraulic scheme. Electromechanical Actuator (EMA) is a rapidly developing system relying on the conversion of electrical energy to magnetic energy and then from magnetic energy to mechanical energy. Moreover, EMS has advantages of eliminating the problems of leakage, contamination and maintenance caused by hydraulic oil. In the past decade, the advances in power electronics make it possible to build permanent magnet synchronous motor (PMSM) controller for higher power applications than was previously possible. Moreover, the availability of high performance permanent magnets has made it possible to reduce the mass of magnet material. Reduced mass results in a low enough rotor inertia, a smaller motor and reduced servo size, to achieve good dynamic response. Therefore, EMA using PMSM is a possible alternative to EHA for spacecrafts applications. This paper is devoted to research on design and performance analysis of recently developed high power EMA applied to spacecrafts whose weight and size are critical. Firstly, the comparison of EMA and EHA is presented briefly. Then, the basic design concept of EMA, utilizing three cascade closed control loops and field oriented control (FOC) of PMSM, is described in detail. Subsequently, EMA performance is analyzed by mathematical simulation and on-ground testing. The mathematical modeling and computational simulation of EMA based on modeling in professional environment are expatiated on. Moreover, the method and results of on-ground testing for EMA are also brought forth. Analytical results demonstrate that EMA performance can be predicted with acceptable accuracy. In conclusion, EMA has achieved the nearly same performance as EHA and being a reality for high power flight control of spacecrafts.