Paper ID: 79877
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30th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Generic Technologies for Small/Micro Platforms (6A)

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FINAL RESULTS OF THE NOVEL ACS DEVELOPMENT PROJECT FERRAC

Abstract

This paper discusses the final results of the Ferrofluid Attitude Control (FerrAC) project, including relevant iterations and lessons learned. This includes a brief discussion on relevant iterations performed and lessons learned. A performance expectation for the most promising final design is given in terms of torque generation and storable angular momentum. Additionally, a design iteration has been tested on the International Space Station adding in-space verification to the project results. One important class of attitude control systems are reaction wheels and control moment gyros. These are mechanical systems, which have been shown be prone to mechanical failure. This usually leads to consuming redundancy, degrading or even failing a mission. Prominent examples of reaction wheel failure are the missions FUSE, Dawn, Kepler, Swift and Hayabusa. Any system with mechanical contact of solid surfaces inevitable experiences wear and tear, limiting reliability and life expectancy. Investigating an alternative approach of ACS design without mechanical wear is the aim of the FerrAC project. The initial goal was to fully replace solid moving components by liquids that can be magnetically manipulated, i.e. ferrofluids. This envisioned storing angular momentum in a circulating fluid loop minimizing the wear problem of solid-solid contact surfaces. During development and testing it became clear that magnetic coupling directly to the ferrofluid is possible but yields insufficient system effectiveness, i.e. torque and momentum storage capabilities are limited and lower than mechanical. counterparts.

The novel iteration is able to achieve competitive performance by using once more a solid rotor with embedded permanent magnets, similar to the conventional mechanical design. Non-mechanical properties are achieved by directly wetting permanent magnets, with ferrofluid. This produces a liquid cushion relatively fixed to the magnet surface position exerting a magnetic pressure to act as a bearing force. Circular arrangements of magnets are utilized to achieve a full 3D ferrofluidic bearing that impedes mechanical contact between rotor and containment walls.

An iteration of this ferrofluid-bearing ACS design has been flown during a 30-day stay in microgravity on the ISS mission FARGO. The subsequent iteration aimed to realize further simplification, as well as effectiveness and efficiency improvements to be discussed in this paper.

The FerrAC project has been executed with the German SME Astos Solutions GmbH, which supported with their industry and in-orbit operation simulation knowledge. It has been funded by the Space Agency within the German Aerospace Center.