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UPDATE ON THE DEVELOPMENT OF FERRAC THE MECHANIC-FREE ATTITUDE CONTROL SYSTEM

Abstract

An update on the progress of the FerrAC project is presented. FerrAC is a component development project to develop attitude control actuators for small satellites based on ferrofluid. It uses results of the ISS experiment PAPELL, which has shown that repeatable and reliable ferrofluid manipulation and transport is possible in microgravity [1].
The idea of FerrAC is to transport ferrofluid in a closed loop through magnetic forces to emulate the principle of a reaction wheel without solid moving parts and therefore reduce wear. Such a system could offer a better demiseability, since its liquid contents would quickly disperse once its containment is breached during reentry instead of the bulk mass to be demised. The system does not require precision machined components such as the flywheels in a traditional reaction wheel or high speed bearings and could therefore its production cost could be lower. Additionally, a concept with a pumping mechanism and custom piping may be adapted to specific satellite geometries. Since the FerrAC actuators are essentially pumps, they may also be used in other fluid transportation applications.
One concept considered in this project is to not move a homogeneous volume of ferrofluid, but instead a two phase system of a ferrofluid and a nonmagnetic secondary liquid. The different magnetic permeabilities of the two liquids allows them to be manipulated similarly to the the rotor of a reluctance motor. The secondary liquid may also have a high density to increase the performance of the system. Several ferrofluid – secondary fluid pairs have been investigated and the liquid metal galinstan and mixtures of water and isopropyl alcohol have been identified to be beneficial.
Different actuator prototypes are currently under investigation. One prototype aims to use a portion of ferrofluid to emulate a piston-pump. Other prototypes use an array of electromagnets similar to the stator of an electric motor to directly accelerate the ferrofluid in an circular loop. The prototypes are to be tested on an low friction rotating test bench.
Overall, actuators developed within FerrAC have the potential to provide an alternative to traditional reaction wheels in attitude control system of small to medium sized satellites.

[1] M. Ehresmann, D. Bölke, S. Hofmann, F. Hild, K. Grunwald, S. Sütterlin, C. Behrmann, N. Heinz, G. Herdrich, R. Jemmali: Experiment Results and post-flight Analysis of the ISS Student Experiment PAPELL, IAC-19,E2,3-GTS.4,2,x50319, 70th International Astronautical Congress, Washington D.C., USA, 2019