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Author: Ms. Laura Breitenbücher
Germany, laura.breitenbuecher@web.de

Ms. Saskia Sütterlin
KSat e.V., Germany, suetterlin@ksat-stuttgart.de
Mr. Manfred Ehresmann
Institute of Space Systems, University of Stuttgart, Germany, ehresmann@irs.uni-stuttgart.de
Mr. Felix Schäfer
Institute of Space Systems, University of Stuttgart, Germany, fschaefer@irs.uni-stuttgart.de
Prof.Dr. Georg Herdrich
Institute of Space Systems, Germany, herdrich@irs.uni-stuttgart.de
Prof. Stefanos Fasoulas
University of Stuttgart, Germany, fasoulas@irs.uni-stuttgart.de

ASSESSMENT OF FERROFLUID INTERACTION WITH SECONDARY LIQUIDS

Abstract

A study of ferrofluid interaction with secondary fluids is presented in this paper. Ferrofluids are superparamagnetic liquids, which can be manipulated with sufficiently strong magnetic fields. The motivation for these investigations is based on the student project PAPELL (Pump Application using Pulsed Electromagnets for Liquid reLocation), which was successfully conducted on the International Space Station in 2018 [1]. PAPELL was designed to demonstrate ferrofluid manipulation in microgravity conditions, and it proved that ferrofluids can be used for a pump mechanism without any moving parts in a microgravity environment. This enables low-maintenance, highly reliable and high-lifetime systems to be developed. For the follow-up project FerrAC (Ferrofluid Attitude Control) these results are applied to develop an attitude control system without any moving parts. Within the attitude control system, ferrofluids are utilized to transport a secondary fluid by using sufficiently strong magnetic fields. The interaction of ferrofluid and secondary fluid is critical for the system functionality, as negative interaction and degradation may occur. Possible ferrofluid degradation effects are briefly introduced. Subsequently, an experiment setup has been designed to investigate ferrofluid degradation effects. For this purpose, samples of selected ferrofluids, relevant for spaceflight application, and secondary fluids have been put into contact and have been observed. Using permanent and electromagnets as magnetic field sources, samples are analyzed by observing their reactive behavior to changing external magnetic fields. In addition, static experiments are performed to simulate long-term exposure to static magnetic fields. Consequently, experiment observations of different combinations of ferrofluids and secondary liquids are compared. These experiments lead to the conclusion that ferrofluids degrade rapidly and irreversible due to their interaction with respective secondary fluids and that an additional long-term exposure to permanent magnets negatively affects many ferrofluid samples. Mixtures of isopropanol and distilled water proved to be a suitable secondary fluid for the ferrofluid APG 313. In the experiments performed, no degradation effects occurred if Galinstan was used as a secondary fluid. Therefore, Galinstan proved to be a particularly suitable secondary fluid. The high density of the liquid alloy Galinstan is of particular interest for attitude control application to store angular momentum in a compact device.

[1] M. Ehresmann, et al. 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.,