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SCIENTIFIC RESULTS OF FERRAS - INNOVATIONS IN FERROFLUID PUMPING SYSTEMS FOR MICROGRAVITY APPLICATIONS

Abstract

The Ferrofluid Application Study (FerrAS) explores the potential of ferrofluid applications in microgravity environments. The primary objectives of this project are to verify two novel pumping concepts - a Displacement Pump (DP) and a Linear Pump (LP) - in microgravity, as well as a respective performance characterization. In addition, conclusions can be drawn about the behavior of ferrofluid in microgravity. The motivation behind this project is to leverage the unique properties of ferrofluids to reduce mechanical friction and eliminate the need for moving parts - a critical point of wear - in fluid management systems in space.

FerrAS is a student project developed by a multinational and interdisciplinary group of 20 students as well as two supervisors from the Institute of Space Systems at the University of Stuttgart (IRS). The students are part of the small satellite student association (KSat e.V.) at the University of Stuttgart. The project was conducted through the German-Swedish student programme REXUS/BEXUS, organized by German Aerospace Center (DLR), Swedish National Space Agency (SNSA) and European Space Agency (ESA).

Ferrofluids are paramagnetic liquids that can respond to external magnetic fields, thereby offering exciting possibilities in a variety of applications, especially in fluid management in space.

The Displacement Pump (DP) experiment aims to develop a ferrofluid-based pumping system. It replaces all critical mechanical parts (drive, piston, seal, bearings) with non-mechanical solutions, i.e. neodymium magnets coated with ferrofluid. By actuating these magnets with external electromagnets, and the resulting vacuum created, a pumping action is generated.

The Linear Pump (LP) represents a technological progression for fine adjustments of attitude control of small satellites. It utilizes a reservoir of ferrofluid that is regulated by electromagnets, effectively substituting the conventional function of the pump piston and thus completely eliminating the need for mechanical oscillating elements. The system operates through a circular fluid circuit, which enables the generation of torques in a targeted and vibration-free manner.

The experiment is launched on the REXUS 31 sounding rocket from Esrange in March 2024. During the flight, the temporal activation of the electromagnets is varied and the flow rate of both pumps is thus specifically controlled. This paper provides a comparative analysis of the performance of the presented pumps in a microgravity environment, comparing them to results of corresponding ground tests.