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PAPELL: FINAL STUDENT EXPERIMENT DESIGN OF A NON-MECHANICAL PUMPING SYSTEM ON THE ISS

Abstract

PAPELL ("Pump Application using Pulsed Electromagnets for Liquid reLocation") is a technology demonstration of a non-mechanical pumping mechanism, which is to be presented in this paper. The teamwork of more than 30 students of the Small Satellite Student Society KSat e.V. with the support of the Institute of Space Systems (IRS) lead to one of the three winning experiments of the "Überflieger" student competition, which is issued by the German Aerospace Center (DLR). This competition calls for the development of three student projects and their conduction on the International Space Station (ISS). The final designed experiments need to comply with the conditions given by a NanoRacks NanoLab Cube of 10 x 10 x 15 cm with a USB-3 connection and a limited power supply of 4.5 W. The development period of one year is given by the DLR. The PAPELL experiment is realized by utilizing the magnetic interaction between electromagnets and hydrocarbon-based ferrofluid. Ferrofluid is a magnetizable liquid consisting of iron oxide nanoparticles and a carrier fluid. It is attracted to sufficient strong magnetic field sources and aligns with presented field lines. By switching individual electromagnets, local magnetic fields are generated. Single ferrofluid droplets are transported along a series of electromagnets. With the removal of mechanical components, friction and abrasion effects are minimized and a high-lifetime pumping system can be achieved. It can be expected that wear and maintenance will decrease significantly, while simultaneously a minimization of vibrations in operation compared to conventional pumps is possible. Ideally, less overall noise, minimal vibration impacts on other payloads and longer operations time are expected. The first part of the experiment is conducted on a hexagonal grid of electromagnets. The transportation of single ferrofluid droplets in linear and complex pattern is analysed. In additional experiments, splitting and merging of droplets and moving of fluid groups is analysed. In a tubular system the second part of the experiment is performed, where in between individual ferrofluid droplets trapped air and injected solid spheres are transported. This shows the transportation capability of the system. Launch to ISS is scheduled for May 1st, 2018 with Antares OA-9. The experiment is part of the "Horizons" mission of ESA astronaut Alexander Gerst. Bulk data for detailed analysis is expected in August. It is expected that the level of basic knowledge gained by this experiment can lead to an extended analysis, verification and validation activity.