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DEVELOPMENT AND PERFORMANCE MEASUREMENT OF FERROFLUID BASED ATTITUDE CONTROL ACTUATORS

Abstract

The current designs and the first performance measurements of the ferrofluid based attitude control actuators developed at the Institute for Space Systems of the University of Stuttgart are presented. The project FerrAC-ACS aims to create mechanic-free attitude control actuators for small satellites by using ferrofluids and electromagnets. The actuators operate similar to a reaction wheel. But instead of rotating masses, fluids are circulated in closed loops to achieve the same effect. This allows them to generate torque without solid moving parts and therefore reduces wear. Other advantages of such systems are improved demisability as the working mass can drain during re-entry instead of having to burn up, lower production cost because no precision machined components are needed and general design adaptability. Additionally these systems can be used as pumps for numerous applications such as material transport or thermal management. The actuators do not move a homogenous mass of ferrofluid, but are operating with a system of two separate fluid phases that do not mix. One of these fluids is the ferrofluid that is manipulated by magnetic fields. A high density liquid is chosen as the secondary fluid to allow storage of larger amounts of angular momentum. One candidate for a secondary fluid is Galinstan, a liquid alloy of gallium, indium and tin, because of its high density, compatibility with ferrofluid and wide liquid temperature range. Because of the different magnetic permeabilities of the two fluids, magnetic reluctance can be used for manipulation. Among the prototypes are the so-called wave pumps. They work similarly to a peristaltic pump and consist of a channel with a lengthwise phase boundary between the ferrofluid and secondary fluid. The ferrofluid is held in place by permanent magnets. Additional electromagnets are used to create waves that impinge on the secondary fluid and move it along the phase boundary. This causes the secondary fluid to flow through the device. The secondary fluid then flows through a closed loop of pipes, that can be adapted to different satellites, before it returns to the pump. The performance of the prototypes is measured using an in-house developed air bearing test stand. It allows the tested devises to rotate nearly friction-less around the vertical axis and an encoder systems allows precise rotation

measurement, that allow the calculation of the torque and angular momentum. These measurements are used to quantify and optimize the designs.