Paper ID: 50594
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IAF MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Facilities and Operations of Microgravity Experiments (5)

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A PROTOTYPE OF MICROGRAVITY FACILITY OPERATED BY LINEAR MOTORS: MOTION PLAN AND CONTROL

Abstract

As human beings make constant progress in space exploration, the demands for simulating microgravity and partial gravity on the ground are expanding. The mainstream ground-based microgravity facilities are drop towers and drop shafts, such as ZARM, Zero-g, NLMC and MGLAB. Such facilities provide microgravity conditions by dropping a capsule, which would perform free-fall motion. Mechanical shock-buffers are equipped to decelerate and recycle the capsules in the facilities, which have two obvious shortcomings. Firstly, the brake decelerations of mechanical buffers, which are usually more than 10 g, are usually harmful to the experiment payload. Secondly, the uncontrollability of recovery takes time for experiment preparation.

Here a novel facility operated by linear-motor with acceleration-controllable abilities is proposed. It can simulate weightlessness and other partial gravity conditions with similar performance with drop tower. In this facility, linear motors are used to provide electromagnetic thrust and accelerate upward and then decouple the carrier. The carrier will do free-fall motion along a vertical parabolic flight, during which the carrier has microgravity conditions. Microgravity experiments can be carried out inside, which could be vacuumized when needed.

This paper emphases the motion planning and control: Firstly, the motion curves are designed; secondly, the overshoot is considered during the motion; thirdly, the capsule is controlled to avoid the contact between the inner-capsule and the outer-capsule. Traditional S-curve-velocity motion plan is frequently adopted in machine tool to avoid the capsule from impact, overshoot and oscillation. In this paper, a novel S-curve motion plan is proposed in order to adapt to motor thrust characteristics better and has better control precision.

A prototype equipped with 3-meters linear motor is built to test the assumptions. The test results verify the feasibility of using linear motors to create microgravity and partial gravity environment. The results show that the dual-pass microgravity duration with short interval is realized. The overshoot and vibration can be reduced by using S-curve motion plan.