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SHOCK RESPONSE CONTROL FOR LANDING OF PLANETARY EXPLORATION SPACECRAFT BY MEANS OF ACTIVE MOMENTUM EXCHANGE IMPACT DAMPER

Abstract

On the landing of the spacecraft on planets such as the moon and the Mars, a large shock load leads to undesirable responses, such as rebound, swing vibration and trip of the spacecraft. In this paper, the authors discuss the control problem of these shock responses by means of Momentum Exchange Impact Damper (MEID); particularly AMEID (Active-MEID). A MEID is compared to a series two-mass system which consists of a controlled object and a mass called "damper". When a shock load is applied to the object, the object's momentum is transferred to the damper's momentum. Thus, the responses of the object keep stable. The MEID is classified into two types. One is a PMEID (Passive-MEID) that is composed of passive elements: linear spring and dashpot. The other one is the AMEID that includes not only passive elements but also active actuators. The AMEID can greatly reduce the influences of shock vibration due to its effective momentum exchange by use of the actuators. First of all, the authors design for simulations a landing system with MEIDs and conduct their modeling in two-legged system. The landing system is composed of a main landing unit and the ground (to be landed). The main landing unit consists of a main body, landing legs and MEID mechanisms. The PMEID mechanism is a one-degree-of-freedom vibratory system. The AMEID mechanism utilizes voice coil motors as actuators in addition to the PMEID components. In order to compare the effectiveness of control systems, we simulate the following three cases of the systems: without MEID, with PMEID, with AMEID. Three kinds of landing styles are also compared – free fall on a flat surface (landing 1), inclining fall on a flat surface (landing 2) and free fall on a step-like terrain (landing 3). In the landing 1, all of the MEID systems can prevent rebound. Particularly, the AMEID system shows significantly high control performance due to the effect of introducing reactive motion of the actuator. In the landing 2, the MEID systems can conduct the control of swing vibration. In the landing 3, the system without MEID tripped over the step. In comparison, the MEIDs can prevent the trip of spacecraft. Especially, the AMEID system can also prevent rotating motion as compared with others. From the above mentioned results, it was verified that the AMEID is superior in the control of spacecraft landing responses such as rebound, swing and trip.