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A NEW HYBRID DUAL-STAGE ELECTROMAGNETIC RAILGUN EQUIPMENT FOR HYPERVELOCITY IMPACT TESTING

Abstract

Since many years, aerospace engineers have been challenged to design space missions that preserve the Earth orbit environment and the spacecraft by minimizing micrometeoroid and orbital debris (MMOD) problem. In order to decrease the probability of spacecraft failure caused by this objects, MMOD shields are needed for spacecraft. High velocity impacts can be simulated using different types of equipment. In this work a new hybrid dual-stage electromagnetic railgun (HDSEMR) equipment assembled and tuned to perform high energy impact test is presented. The in house built HDSEMR consists of a first stage made of a light-gas gun (LGG) to impress a substantial initial speed to the armature-projectile and a second stage made of an electromagnetic railgun able to impart the acceleration required to reach the final desired speed. An experimental LGG should operate in a similar way to a conventional gun with powder. The main difference is constituted by the means of achieving the necessary pressure to accelerate the projectile. As a conventional gun employs the combustion of a propellant charge, a light-gas gun operates with a compressed gas reservoir. The electromagnetic accelerator, called railgun, is an electrically powered electromagnetic projectile launcher. It is made up of a pair of parallel conducting rails, along which a sliding metallic armature, that can have both the function of projectile or projectile driver (armature + sabot + projectile), is accelerated by the electromagnetic effect (Lorentz force) of a current that flows down one rail into the armature, and then back along the other rail. The rail bars are electrically connected to a bank of high voltage capacitors (in this case 6000 V 72 F) and a tunable power supplier is used to set the capacitors charging voltage at the desired level: by this way the energy of the apparatus can be easily tuned as a function of the desired bullet velocity. A mathematical modeling based on Maxwell-Lorentz equations and on the railgun physical parameters has been introduced in order to link the bias voltage to the projectile firing velocity. Test with bullets fired at speed in the range 2-3 km/s have been performed on composite-metallic hybrid multilayer panels. A numerical analysis is also performed by using an appropriate code in order to analyze the performance of the hypervelocity impact test equipment. The experimental results and the numerical simulations show that the device is a good candidate to perform reliable space debris impact testing.