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Emerging Global Space Ventures, including Reusability and other Innovations (9-D6.2)

Author: Dr. Tadayoshi Shoyama
Chiba Institute of Technology, Japan

Dr. Yutaka Wada
Chiba Institute of Technology, Japan
Mr. Yosuke Furuta
AXS Corporation, Japan
Mr. Noboru Kurata
Sowa Engineering Corporation, Japan
Dr. Daisuke Ode
Obayashi Corporation, Japan
Mr. Shouji Horiuchi
Kuroiso Manufacturing Company, Japan
Mr. Takuji Sonoda
Ube Kohki Co., Ltd., Japan
Prof. Takafumi Matsui
Chiba Institute of Technology, Japan

LT FUEL/N2O HYBRID ROCKOON WITH AN ELECTRICALLY DRIVEN TURBOPUMP

Abstract

Hybrid rockoon, that is, a hybrid rocket launched from a balloon has many synergetic advantages. The propulsion performance of hybrid rockets can be increased by elevating the ignition altitude to the upper atmosphere where a nozzle with a large expansion ratio is applicable. Safety issues of rockoons with respect to fall accidents of explosive propellant does not exist in hybrid rockets because each propellant is not explosive. A preliminary design of hybrid rockoon was performed for single-stage suborbital missions and multiple-stage orbital missions, aiming at sampling cosmic dust levitating in the upper stratosphere. The dimensions and inertia properties were determined considering the range-safety requirements, and three-dimensional launch trajectory analyses were conducted. The hybrid rocket uses low-melting-point thermoplastic (LT) fuel and N_2O as the propellants, which have advantages because of their mechanical properties at the cold temperatures experienced in high-altitude environments. A self-pressurized 5kN hybrid rocket motor was developed and ground firing tests were conducted successfully. The saturation vapor pressure drops to 0.7 MPa at the atmospheric temperature at an altitude of 20 km where the hybrid rockoon is ignited. Because it is too low to be injected to the combustion chamber, the liquid N_2O is pressurized by using an electrically driven turbopump. A preliminary design of the pump was performed, including the CFD analysis of the three-dimensional flow in the impeller, inducer, and volute. The rotor is supported by propellant lubricated journal bearings, and a bearing test rig is under construction. A suspended rail launcher lifted by the balloon was studied. It has attitude control capability with control moment gyroscope (CMG). Small model rockets were successfully launched to demonstrate the feasibility of the CMG controlled launcher. In the experiment, the rail launcher was suspended by a crane, instead of a balloon. A pendulum motion in the elevation angle was observed and the behavior was discussed with a dynamical model representing the suspended launcher. The details about the research and development of these rockoon technology are reported.