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Author: Prof. Kyun Ho Lee
Sejong University, Korea, Republic of, khlee0406@sejong.ac.kr

Mr. Joong Won KuK
Sejong University, Korea, Republic of, xndzl@naver.com

PLUME ANALYSIS OF ADN GREEN PROPELLANT THRUSTER FOR SATELLITE ATTITUDE CONTROL

Abstract

Generally, toxic and carcinogenic hydrazine propellants are commonly used in spacecraft propulsion. With an increasing level of future space activities and applications, the significance of lower toxicity propellants called as "Green propellants" becomes even more pronounced currently. Recent commercial and government investments have resulted in substantial advances in the technology readiness of a number of new candidate green propellants, many of which have already completed, or will complete in the next few years, successful on-orbit demonstrations. These propellants are often touted as potential replacements for conventional hydrazine. For example, the use of hydrogen peroxide as a monopropellant dates back to the earliest days of modern rocketry in the early 1930s, whereas new propellants such as ammonium dinitramide (ADN) and hydroxyl ammonium nitrate (HAN) were developed by the Swedish Defence Research Agency (FOI) and the Air Force Research Laboratory (AFRL). However, to the best of the authors' knowledge based on a literature review, detailed studies of the exhaust plume flow behaviour of the green monopropellants have not been presented yet because current developing activities are focused mainly on the performance verification of the thruster unit level rather than its impacts on the spacecraft system. As the plume flow behaviours greatly depend on the chemical characteristics of the propellants used, accurate prediction and assessment on the plume flow influences of the green propellants shall also be evaluated inevitably during a spacecraft development process. Thus, the purpose of the present study intends to investigate the plume flow behaviours of a green monopropellant and also to compare major differences with the conventional hydrazine propellant for the first time. Here, ADN is chosen as a representative green monopropellant especially because it has been verified successfully in the space environment. To ensure a numerical efficiency, the calculation domain was composed of three different subdomains depending on the physical conditions of the plume flow. By applying the appropriate numerical methods to each subdomain sequentially, individual calculated results were used as initial boundary conditions for other methods. Consequently, the present results are expected to provide useful information on the ADN green monopropellant by investigating the characteristics of highly rarefied plume flows exhausted from a small thruster, which can be very helpful for actual engineers practically during the design process.