Paper ID: 65655
student

IAF SPACE PROPULSION SYMPOSIUM (C4)
New Missions Enabled by New Propulsion Technology and Systems (9)

Author: Mr. ILYES GHEDJATTI
Beijing University of Aeronautics and Astronautics (BUAA), China, ilyes.ghedjatti@buaa.edu.cn

Dr. Shiwei Yuan
Beijing University of Aeronatics and Astronautics, China, yuanshiwei@buaa.edu.cn
Prof. Haixing Wang
Beijing University of Aeronatics and Astronautics, China, whx@buaa.edu.cn

OPTIMIZATION OF LASER AND OPTICS SYSTEM PARAMETERS FOR PERFORMANCE BOOSTING IN AEROSPACE PROPULSION APPLICATIONS

Abstract

The need to realize more efficient ignition systems and exploit its full potential in aerospace propulsion applications has led to significant developments of laser ignition and power systems. This work aims, first to investigate experimentally and numerically the effectiveness of laser parameters variation and its effect on energetic materials' sensitivity and ignition threshold, then to define the key variables that have more influence on the overall system, finally to theoretically apprehend the effect of laser parameters variation on the ignition and combustion performance, as well as on the specific impulse variation and thrust control. This work can be separated into two steps, in the first step, boron potassium nitrate has been considered for laser ignition, while the second step concerns an extended numerical model established from the obtained experimental results and then applied to a variety of energetic materials that are used in rocket propulsion applications. This helps optimizing the laser and optics system parameters for performance boosting in rocket propulsion applications. Ignition energy depends on the laser output power, pulse width, angle of incidence, spatial beam uniformity, beam quality and optical properties. In the experimental part, the focal length, beam quality, focal spot size and energy density are varied using a lens system composed of collimating and focusing lenses, beam splitters, and adjustable and nonadjustable lens tubes. The corresponding effects on ignition energy and time-to-ignition are recorded for both conditions of continuous and pulsed modes. The influence of apertures and focal lengths on laser beam profile, beam quality factor and pulse energy are discussed. Relationships between key variables and irradiated medium are established, and pulse-to-pulse energy variations related to optical properties are investigated. The estimation of the aforementioned key parameters, the calculation of combustion performance, and the optimization algorithms and optimal solutions are realized via Python. Further parameters are considered using the Python package, and conclusions are made. Understanding the physics and chemistry behind the combined system of laser power source and optics system, and the considered medium, as well as the interaction in between, will lead to a better apprehension on how can an optimal and viable solution be achieved amid difficult conditions during outer space operations, particularly those involving manned missions, not only in terms of performance and operability, but also safety, and engineering and economic feasibility.