Paper ID: 72907
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IAF SPACE PROPULSION SYMPOSIUM (C4)
New Missions Enabled by New Propulsion Technology and Systems (9)

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LASER BEAM BRIGHTNESS AND FOCAL LENGTH VARIATIONS AS KEY PARAMETERS IN ACHIEVING LOW IGNITION ENERGY OVER INCREASING DISTANCES WITH LOW IGNITION TIMES AND HIGH COMBUSTION TEMPERATURES

Abstract

The need to realize more effective laser systems and exploit their full potential in aerospace applications has led to significant developments of lasers, optical systems, and laser-powered systems. To have a better understanding on what influence the variation of laser parameters would have on a specific medium, and to be able to achieve optimal conditions and effective operations at a very low cost, Boron Potassium Nitrate (BPN) has been used and at which a laser beam from a laser diode is directed. The purpose of this study is to investigate the relationship between the laser parameters variation and the nature of the targeted medium. To support our results and conclusions, achieving ignition with a very low input power over an increasing distance separating the source from the energetic material is deemed as evidence of this design effectiveness. However, in contrast with some of the available outcome in the literature as in most of the studies carried out to date, the ignition energy and reaction times at the target would vary with the input and output power, pulse width, angle of incidence, spatial beam uniformity, beam quality and optical properties. For instance, the ignition time increases with the decrease of the ignition energy, and similar results are expected if the distance separating the source and the target increases. In this study, these phenomena can be reversed in a way that the output power and delivered ignition energy would not change, or even kept at very low values, while the source-target distance is increased. This can be achieved by manipulating and controlling parameters that are of a paramount importance, such as, but not limited to, laser brightness and beam diameter variation, focal length displacement over the source-target distance, as well as the absorptivity of the targeted medium, its mass and sensitivity. The most noticeable fact is that optimal results can be easily achieved if these parameters are controlled simultaneously, and thus decreasing the ignition times and increasing combustion temperatures, while requiring very low energy values. Numerical models describing this system have been established and conclusions made. Understanding the physics and chemistry behind the combined system of laser power source and optics system, the considered medium, as well as the interaction in between, will lead to a better apprehension on how optimal and viable solutions for aerospace applications can be achieved amid difficult conditions, particularly in outer space operations.