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Title

Nitromethane as a Green Propellant: First Results of a Combustion Test Campaign

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Abstract

Because of its carcinogenic and toxic nature, the use of hydrazine in space propulsion is associated with high costs and a large bureaucratic overhead which can significantly endanger cost- and time-planning in space programs [1]. In order to negate this drawback significant R&D activities all over the world took place within the past 20+ years. So far one of the most promising approaches to replace hydrazine monopropellant systems in spacecraft is through the use of energetic salt-based ionic liquid propellants. In this kind of propellants energetic salts such as ADN or HAN are dissolved in water and then a fuel component such as methanol or ammonia is added along with additives and stabilizers. LMP-103s, HNP209 and ASCENT are the most important commercially available propellants based on this approach [2]. Although these propellant solve many problems associated with the use of hydrazine, propellant production is quite costly because it involves the handling of energetic substances. An alternative and a less costly approach to "green" monopropellant propulsion is the use of nitromethane – a staple laboratory solvent. Although also an energetic substance, nitromethane is not considered an explosive and is widely available in bulk at a low cost. Furthermore, Nitromethane has a similar mass-specific impulse as other green monopropellants ($I_{sp,NM}$ = 2609 m/s; [ρ_{NM} / ρ_{H2O}] * Isp = 2974 m/s, flow frozen at throat, p = 20 bar, ε = 100). Our previous work was focused on the safety aspects of the use of nitromethane as a liquid monopropellant. We succeed in significantly lowering the BAM Fallhammer impact sensitivity (i.e. rising the energy needed to detonate liquid nitromethane) [3] by adding inhibitors. In this paper we will present first results of a combustion chamber test campaign. We will elaborate on the test hardware, on the ignition and the test sequences, the evaluation methods and, of course the results and performance. The first results indicate a lower combustion pressure threshold of 20 bar (vs. 35 bar in pure nitromethane) and a combustion efficiency of 90 %. This means that approximately 85% of the theoretical specific impulse of pure nitromethane could be reached if our preliminary propellant mixture would be used in spacecraft or satellites.

References

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