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CONCEPTUAL DESIGN OF AN UPPER-STAGE PARAFFIN-BASED HYBRID PROPULSION SYSTEM

Abstract

Environmental and economic reasons are pushing towards the replacement of hydrazine-based propulsion units with more convenient choices. An alternative solution for some applications can be represented by hybrid rocket technology. Hybrid rockets allow for throttleability, multiple ignitions while being very safe systems due to the physical separation of fuel and oxidizer in solid and liquid form respectively. Recent implementation of paraffin fuels with suitable performance levels can lead to propellant mass savings, maintaining an environmentally friendly propellant. As drawbacks, hybrid rockets are featured by limited regression rates; brittle nature of the paraffin is a limiting factor for large scale use of paraffin as a solid component of the propellant; and the combustion chamber varies its geometry in time. In the perspective of a potential replacement of hydrazine-based systems, this paper considers the fourth stage of VEGA launcher AVUM as a benchmark and explores the possibility to use a paraffin-based hybrid motor instead of its UDMH/NTO liquid engine. The investigation takes into consideration mission specifications (DeltaV and payload mass) and considers the potential application of different oxidizer choices with paraffin strengthened with a thermoplastic polymer SEBS. The design of main components such as fuel grain, combustion chamber, nozzle, oxidizer tanks and pressurization system tanks is obtained aiming to maintain the geometry of the existing AVUM stage. Performance parameters, estimation of masses, thrust and their variation during firing are calculated. The preliminary design shows that a hybrid motor (paraffin-based fuel/LOx) fits the existing geometry in terms of length and overall diameter. The total propellant mass is 320 kg that is within the range of AVUM's load mass (250-400 kg) and which can give a possibility to carry a larger payload.