

IAF SPACE PROPULSION SYMPOSIUM (C4)
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SYSTEMS ADVANTAGES OF ELECTRIC PUMP FED UPPER STAGE HYBRID ROCKET

Abstract

Choice of propellant pressurization system highly effects the subcomponents' size and weight of a propulsion system, so it is critical for performance optimization. In conventional systems, liquid propellants in liquid or hybrid rockets are fed into the combustion chamber using a turbo pump or a pressurizing gas. However, with the developments in electric motor and battery technologies, solutions once proven inefficient are quickly becoming feasible. Electric motors and batteries with high power density enable electric pumps for being used in rocket engines. In an upper stage motor with low chamber pressures, these high-power density components lead to a system with lower structural mass fraction and therefore lighter and potentially simpler system for the same mission. Electric pump feed systems have been parametrically analyzed in liquid engines and a noticeable performance improvement has been presented (Rachov, Tacca and Lentini (2010). ELECTRIC FEED SYSTEMS FOR LIQUID PROPELLANT ROCKET ENGINES. Research Report). This technology is even more advantageous for hybrid rocket motors, since there is only one liquid propellant to pressurize. Casalino and Pastrone have shown the advantages of such system on an optimized upper stage hybrid motor (Lorenzo Casalino and Dario Pastrone (2010). "Optimization of a Hybrid Rocket Upper Stage with Electric Pump Feed System", 46th AIAA/ASME/SAE/ASEE Joint Propulsion Conference Exhibit, Joint Propulsion Conferences). This paper focuses on a system study for an electric pump pressurization system and a comprehensive comparison between gas pressurized and electric pump pressurized systems. In both systems, system weight is minimized over a number of component parameters and a specified mission by a genetic algorithm. During optimization, phenomena like nozzle erosion and grain cooking from long burn times are addressed and burning times are optimized along with the battery capability. For optimized systems, weight analysis is made and a comparison between the two is discussed. A simple cost driver comparison is also included in the paper.