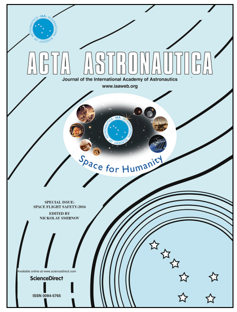
Accepted Manuscript



Analysis of lithium-combustion power systems for extreme environment spacecraft

Christopher J. Greer, Michael V. Paul, Alexander S. Rattner

PII: S0094-5765(18)30394-1

DOI: 10.1016/j.actaastro.2018.05.039

Reference: AA 6895

To appear in: *Acta Astronautica*

Received Date: 23 February 2018

Revised Date: 9 May 2018

Accepted Date: 18 May 2018

Analysis of Lithium-Combustion Power Systems for Extreme Environment Spacecraft

Christopher J. Greer[1], Michael V. Paul[2], and Alexander S. Rattner[1]*
[1]*The Pennsylvania State University, State College PA, 16802*
[2]*Johns Hopkins University Applied Physics Laboratory, Laurel, MD, 20723*

Keywords: Venus, Europa, Lithium, Power, Stirling

Abstract

The longest duration mission on the Venus surface was Venera 13 at just over two hours. This time constraint was due to limited battery power life and craft thermal management challenges. A lithium combustion based power system has been proposed to increase landed mission durations for Venus and other extreme environment targets. This paper presents a new detailed thermodynamic and heat transfer model of a conceptual lithium combustion power system. Findings are applied to specify engineering requirements for potential missions. Results indicate that a lithium combustion power system using the in-situ carbon dioxide atmosphere as an oxidizer could power a Venus lander for up five days (24 hour, Earth day) with 185 kg of fuel, delivering 14 kW_{th} thermal energy continuously. Even greater durations are possible if lower power missions are considered. The potential performances of a Li-CO_2 powered Stirling engine and sulfur-sodium batteries were compared. It was found that sulfur-sodium batteries would require about 1.75-2.5 times more mass to provide 1 kW of power output for mission durations of five to ten days, respectively. A lithium combustion power system with a sulfur-hexafluoride oxidizer could power a Europa lander at 94W with a Stirling engine for up to twenty days with 43 kg of reactants mass. Lithium-combustion activated Stirling engines and TEG arrays were compared with batteries to meet this power and mission duration requirement. It was found that batteries would require less mass than either lithium-fueled system. However, for mission durations longer than twenty-six days the Stirling engine power system may require less total mass than batteries.