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IAF SPACE POWER SYMPOSIUM (C3)
Space Power System for Ambitious Missions (4)

Author: Mr. Nicolas Rey-Tornero
Commissariat à l'énergie atomique et aux énergies alternatives (CEA), France

Dr. Carlos-Jesús Romero-Casado
Commissariat à l'énergie atomique et aux énergies alternatives (CEA), France
Dr. Guillaume Campioni
Commissariat à l'énergie atomique et aux énergies alternatives (CEA), France
Dr. Daniel Heuer
Centre National de La Recherche Scientifique (CNRS), France
Dr. Nicolas Jonquères
Commissariat à l'énergie atomique et aux énergies alternatives (CEA), France
Dr. Sébastien Le Martelot
Centre National d'Etudes Spatiales (CNES), France

MODULAR DESIGN OF A SPACE MW-LEVEL POWER SYSTEM USING A MOLTEN SALT REACTOR

Abstract

Currently developing projects with ambitious goals such as lunar orbital stations, moon bases, multi-mission solar system explorations and Mars human exploration raise the question of dense, controllable, reliable, safe and powerful power supply.

Present work consists in a modular proposition of a MW level power system using a molten salt reactor as primary heat source. We studied different options for the energy conversion system: a potassium or a mercury Rankine cycle combined with a simplistic Heat Pipe Radiator (HPR) or a Liquid-Solid Droplet Radiator (LSDR) as proposal for the heat sink. A simple study of the anti-radiation shield has also been lead.

This paper proposes two configurations for two applicative cases, from a performance point of view, and discusses modulations of the global system for others applications. The criteria of specific mass has been chosen as performance indicator, since it represents a relevant indicator for any space power supply.

First case concerns an unmanned space probe, second is a manned spacecraft. Both cases share the same reactor design and weighs around 1.5 tons. Shield results from radiation limits considerations and weighs about 1 tons. Proposed conversion system with the corresponding heat sink results from an optimization study on various Rankine cycles and heat sinks combinations. A Rankine cycle using potassium or mercury as working fluid, coupled with a Heat Pipes Radiator (HPR) or a Liquid-Solid Droplet Radiator (LSDR) have been analyzed. The optimal option is a combination of a high temperature potassium Rankine cycle combined with a eutectic aluminum-germanium LSDR. This proposed option weighs about 6 tons, reaching 8.5 kg/kWe.

Despite the two detailed proposals, it is relevant to put things into perspective. LSDR and potassium Rankine are in fact lesser-developed technologies. Thus, the idea of modularity: for a swifter implementation, the combination of a mercury cycle with a water heat pipes radiator would be better, although

not optimal from the specific mass criteria doubling it to 16.5 kg/kWe. Likewise, the previously proposed shield design reuses long dated ideas, structure and materials. Other designs currently under investigation may lead to a simpler shield, although heavier.