PERFORMANCE OF RADIOISOTOPE POWER SYSTEMS AT TITAN SURFACE CONDITIONS : A SIMPLE MODELING APPROACH

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ABSTRACT

Like other energy conversion devices, the performance of Radioisotope Power Systems (RPSs) for spacecraft depend on the heat transfer boundary conditions. In planetary environments, the heat transfer, and thus the RPS operating conditions and performance, may be different from those in free space. In particular, I develop a simple model for the performance of an ASRG (Advanced Stirling Radioisotope Generator) in the thick, cold atmosphere of Titan.

The model, essentially an endoreversible heat engine with a specified heat sink and thermal short, operates as follows. We assume a constant radioisotope heat source in steady state: this heat flow is split between the Stirling converter and a thermal short. The two flows are then rejected to the environment from a 'radiator'. The heat rejection parameters (based on radiator area and emissivity, the sky temperature, and a convective heat transfer coefficient to the ambient air – which is the dominant loss term at Titan) define the 'cold' end temperature, from which the hot end temperature is calculated from assumed engine and heat leak parameters. The temperatures then define the Carnot efficiency, from which the engine electrical output is calculated. Output is maximized when the heat leak is small and the heat rejection is enhanced. The unknown heat flow parameters are tuned to reproduce published ASRG performance data : convective heat transfer is estimated from Huygens measurements.

It is shown that the power output of an ideal RPS in the Titan environment could in principle be considerably superior to that in space vacuum by some tens of per cent, although an internal heat leak of the present ASRG design may compromise this improvement, resulting in an output close to, or even smaller than, the predicted vacuum output. These competing factors suggest that performance testing of an ASRG in a representative environment is urgently needed.