SPACE POWER SYMPOSIUM (C3)
Space-Based Solar Power Architectures / Space & Energy Concepts (1)

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SOLAR-POWERED FREE-PISTON STIRLING – LINEAR GENERATOR MODULE CONCEPT FOR A MOON BASE

Abstract

A number of Moon based power systems concepts have been developed by the moment. But neither of them seems to be much better than others due to different power source, converter or storage issues considered elsewhere. Due to high reliability demands a scalable converter able to be coupled with different energy sources with minor efficiency loss is preferable. The greatest problem for solar powered systems is a need for 350 hrs energy storage. This seems realistic only at lunar resources use, the easiest option is for thermal energy storage. Operation conditions require high reliability through 100k hrs without service. But direct converters have low efficiency and mass specific power, and for machine converters this seems real and is proven for Stirling engines only. Reduction of mechanical connections and rotation to linear motion substitution should help to improve converter reliability. Recent progress in linear generators allows considering them as a proper alternative to rotary ones. Using regolith (lunar soil) for heat accumulation should be mainly considered in terms of material mining, preparation, loading, storage and distribution being implemented using brought facilities (not one-purpose preferably). The performed analysis shows that thermochemical storage fits well demanded temperature range and has ca. 20 times less weight, than analogous encapsulated phase-change material one. The most compact heat-exchange surface configurations for both hot and cold Stirling sides seem to be slit ones. Piston is connected to a linear alternator slider, being driven back by a gas spring. There's a tradeoff between alternator weight (cubic frequency) and engine lifetime (linear frequency), which is resolved at ca. 100 Hz. So we suggest to build the following 24 kWe modules: lithium heat pipes-based cylindrical cavity solar receiver (150 kWt @ 1182 K), through-flow thermochemical energy storage (18.3 t of CaH2 <-> Ca (from regolith) + H2 (from water), 62 kWt, 1050 K), water cooled free-piston Stirling engine (26 kWm, 100 Hz), linear generator (24 kWe), vapor inflatable annular emergency heat sink (34 kWt). Stirling engine technology is being developed at BMSTU since 1981, after mid 1990-s peak of research interest it turned to less published implementation works. At the moment technology is developed to an industrial level, but Stirling-based systems design still needs improvement taking into account recent progress in materials science, electrical engineering, and renewable energy facilities implementation experience. Testing experiments for system scale model and its elements are performed at "Beam-M" facility (RFMEFI59014X0001).