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

Author: Dr. Ingo Jahn
University of Queensland, Australia, i.jahn@uq.edu.au

Ms. Sarah Corbet
University of Queensland, Australia, sacorbet@bigpond.net.au
Mr. Javier Rangel
University of Queensland, Australia, f.rangelmacias@uq.net.au
Dr. Joshua Keep
University of Queensland, Australia, j.keep@uq.edu.au

FEASIBILITY STUDY OF A LUNAR-BASED CONCENTRATED SOLAR POWER PLANT

Abstract

Humans have strived to achieve a permanent presence in space, with long-term colonisation in mind. Since space stations have already been proven to be a practical method for this, the next step would be to establish a permanent lunar base. There are many benefits of developing a lunar base, however the systems required for a permanent human habitat need to be investigated and developed. As a response to the Mohammed bin Rashid Global Space Challenge, a project was completed to investigate the feasibility of using a Concentrated Solar Power (CSP) Plant on the moon for powering a lunar base. The investigation included analysing different heat cycles to make the most of the lunar environment and its ambient temperature variations, optimising a solar field to achieve high efficiency whilst reducing the overall weight of the system, and investigating the use of lunar regolith as a heat storage medium.

The team developed a full system with a continuous $100kW_e$ nominal output, a $300kW_t$ solar field input, a maximum temperature of 1250K, and a minimum temperature of 300 and 200K. The heat engine is based on a Recuperated Brayton Cycle (RCBC), with argon as the working fluid. Different heat sink systems were investigated, including the possibility of using space heaters for habitats and radiative coolers that can reject between 10 and 38.2kW. The solar field was optimised for the specific lunar locations, with the central tower using a Falling Particle Receiver (FPR) setup. The lunar regolith was used in the receiver as a heat transfer "fluid", heating up to a maximum temperature of 1250K as well as being the thermal storage medium used to provide night time power. A particle-fluid heat exchanger is employed to transfer the heat to the argon.

This work has applications for any space settlement where thermal energy and heat engines are considered as part of the power solution. Potential applications include other celestial bodies such as Mars, as well as larger scale lunar bases. Future investigations include looking at optimising the system for the lunar day and night cycle, utilising the ambient temperatures at each stage and ensuring the optimal utilisation of power at all times.