

SPACE POWER SYMPOSIUM (C3)
Advanced Space Power Technologies and Concepts (3)

Author: Prof. Sergey Finogenov
Moscow Aviation Institute (National Research University, MAI), Russian Federation

Prof. Oleg Kudrin
Moscow Aviation Institute, Russian Federation
Mrs. Kolomentseva Ludmila
Moscow Aviation Institute (National Research Institute, MAI), Russian Federation

EFFICIENCY INCREASE OF STIRLING ENGINE AS AN ELEMENT OF SPACE SOLAR POWER
PLANT

Abstract

State-of-the-art researches of high-temperature space solar power plants (SSPP) suppose to use, in particular, energy converters with gas-piston Stirling engines (GPSE) use. In case of GPSE usage as an element of SSPP, concentrated solar radiation is supplied through transparent wall to solar energy absorber, where gaseous working medium is heated up to temperatures 1100-1500K. This requires creation of effective concentrator-absorber system (CAS).

Thermodynamic efficiency of GPSE is increased with gas heating temperature; however CAS efficiency is decreasing with absorber temperature increase. Main losses in this case are connected with absorber emissivity. Therefore development of construction allowing decrease absorber emissivity and raising optimal temperature of gas heating and increasing the GPSE efficiency is expedient. Expedient thermodynamic cycles for such GPSE are also considered.

The possible way of GPSE efficiency increase consists in organization of periodic supply of concentrated solar rays to absorber by use of shutter with mirror cover, which overlaps absorber entrance aperture at certain moment of time after gas heating in expulsive volume of the GPSE. Movement of working piston must be connected with phase of solar energy supply. Decrease of absorber emissivity due to partial overlapping by the shutter during working circle allows to decrease total heat losses.

The positive effect of the shutter use can be increased at low concentrator accuracy. It is important in case of inflatable thin film concentrator due to large focal sunspot sizes and the absorber entrance aperture that is accompanied by emissivity rise from the absorber.

The positive effect at periodical supply of solar radiation can also be increased with the absorber temperature growth. In case of absorber with high temperature of gas heating (1500) and non-accurate thin-film concentrator (an angular error of surface 2,5 degrees) relative gain in the GPSE efficiency at use of the shutter can exceed 50 percent. This value directly influences on power and weight of SSPP and the CAS overall dimensions. It is shown that at level of an orbit of Mars periodic heating of the absorber leads to higher relative gain in efficiency in comparison with near-Earth conditions. Use of SSPP with the GPSE is more effective at short distances from the Sun where efficiency of photovoltaic converters should be decreased. At level of orbit of the Mercury at use of large thin film concentrator (diameter 10 m) power of such SSPP reaches 170-190 kW. Efficiency of solar energy conversion into electricity approaches to 25-28 percent.