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

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MATHEMATICAL MODELING OF MIRROR CONCENTRATING SYSTEM FOR SPACE HIGH-TEMPERATURE SOLAR POWER PLANT

Abstract

High-temperature solar power plants (HTSPP) are intended to provide a consumer with thermal energy by means of acquiring and processing solar radiation. As a result, high temperature is achieved in a working zone. This energy can be further used either directly (for example in solar thermal propulsions or smelting units), or it can be converted into electricity by means of machines or thermionic emission generators.

By reason of relatively low solar radiation flux on orbit of the Earth, the development of high-efficiency HTSPP necessitates the use of solar concentrators as part of them. For the same reason the creation of high-power (MW-range) HTSPP necessitates the development of large-sized mirror concentrating systems (MCS), with stringent requirements for their shape and reflecting surface quality being met.

The use of inflatable rigidizable constructions allows the creation of MCS, having sufficiently high accuracy, reliability, as well as low weight and minimum volume in the transport position (it is extremely important for space applications). Therefore at the present time this approach is one of the most promising ones.

At design of such systems it is necessary to have rather reliable and cost-effective methods and tools allowing to analyze characteristics of various configurations MCS and to predict it depending on operating conditions and, therefore, to choose the most suitable system for specific tasks.

Experimental determination of various configurations, especially large-size, MCS parameters requires to conduct a number of complicated and expensive experiments. Moreover, the resulting experimental data applicability is restricted with significant constraints (experimental data can be considerably affected by radiation spectrum of irradiator, quality of reflecting surface) and also restrictions imposed by dimensions of the structure and existence of gravity. Therefore it is of particular interest to develop a mathematical model capable of estimating power characteristics of complex MCS considering the influence of operating conditions, design features, strains, roughness and other surface defects.

In this regard the mathematical model of radiation heat transfer based on use of Monte Carlo methods and finite element method, and allowing to define main characteristics of various configurations MCS taking into account influence of listed above factors was developed and realized in the software package.

Mathematical modeling allows to perform rational design through analyzing a large number of design solutions for maximizing power and mass efficiency of HTSPP and reducing material costs for it design and testing.