SPACE PROPULSION SYMPOSIUM (C4)
Advanced and Combined Propulsion Systems (8)

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

Prof. Alexander I. Kolomentsev
Moscow Aviation Institute, Russian Federation
Mrs. Kolomentseva Ludmila
Moscow Aviation Institute (National Research Institute, MAI), Russian Federation

ASSESSMENT OF EFFICIENCY OF SOLAR THERMAL PROPULSION WITH MULTI-STAGED CONCENTRATOR-SPECTRAL SELECTIVE ABSORBER—THERMAL ENERGY STORAGE SYSTEM

Abstract

State-of-the-art developments of solar thermal propulsion (STP) assume elaborations of simple single-stage Concentrator-Absorber-Thermal Storage systems (CATS) as a power source. An absorber is ordinary considered as isothermal with one stage of heating, combined with graphite thermal energy storage discharged on active legs of multi-burn injection trajectory. Efficiency of such power source is strongly reduced with growth of temperature of heating that leads to necessity of development of bulky accurate concentrator of solar energy and represents a difficult design problem.

CATS efficiency can be increased by use of multi-staged Absorber-Thermal Energy Storage system with a spectral-selective surface of heating. In the simplest case two-staged absorber with peripheral part connected with thermal energy storage, containing heat-accumulating material (HAM) with relatively low temperature of fusion, and central high-temperature part connected with high-temperature secondary thermal storage, containing HAM with high temperature of fusion, is considered. Materials with high latent heat of fusion, such as beryllium oxide for the high-temperature stage of heating (above 2800K), and beryllium hydride for the lower-temperature stage (960K) are considered. Propulsive mass (gaseous hydrogen), consistently passing through the stages of the thermal energy storage, heats up to high temperatures, providing high specific impulse of such STP (850 sec and higher). Demanded accuracy of concentrator and requirements to its Sun tracking conditions can be reduced in comparison with ordinary considered CATS.

Spectral-selective covers of stages of such absorber allow to increase their absorptive ability in a visible part of the solar spectrum and to reduce emissivity in the field of infrared heat radiation of the absorber. Energetic efficiency of such spectral-selective absorber can be considerably increased in comparison with ordinary absorbers. The staged construction allows lifting additionally energetic efficiency of the CATS, operating at high temperatures. Requirements to concentrator surface tolerance and accuracy of its orientation to the Sun at use of the staged absorber with spectral-selective surfaces can be considerably reduced that strongly simplifies a problem of creation of concentrator and its deployment in space, simplifies an attitude control system and the Sun tracking conditions as well as facilitates operation of such engine in space at the tasks of inter-orbital transfer missions.