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THERMOACOUSTIC POWER GENERATOR FUELED BY A SOLAR COLLECTOR SYSTEM THERMAL ANALYSIS

Abstract

By following the trend of research on the use of thermoacoustic devices for power generation on-board of space vehicles, the present paper addresses an accurate thermal modelization of the whole system; a system that is composed of a thermoacoustic engine itself and a paraboloid mirror which collects solar energy. The purpose of the study is to show a detailed temperature estimation in some critical components of the engine in order to simulate performances. Tipically, the utmost important part of a steady state wave device is the acoustic amplifier, also called "stack", across which a suitable temperature gradient must be established to trigger and sustain the acoustic wave. The heat exchangers at the opposite ends of the stack must then have a certain temperature. The hot exchanger is located at the focus of the paraboloid where the concentrated solar energy impinges on the external surface of the exchanger and it is partially re-emitted and partially transmitted by conduction towards the adjacent parts. The cold exchanger extracts heat from the stack and wastes it into the deep space. The radiative and conductive couplings of the exchangers with all of the other components of the system must therefore be accurately modelized for a reliable temperature prediction. The thermal analysis has been carried out for two different system layouts. The first one concerns a real 2 m diameter fiberglass paraboloid, formerly used as a meteorological antenna and later transformed in our lab into a solar collector by means of a highly reflective film applied on its surface. The second configuration has an ideal shape, optimized for a better input of the heat load onto the hot toroidal shaped exchanger. The solar collector has been taken as a surface of revolution of a double parabola with the axes shifted off the toroid diameter. Such bi-paraboloid has therefore an annular focus and the curvature is such that it is located very close to the vertex so that the cold part of the engine is placed outside the collector, on the opposite side with respect to the sun. Such design improves significantly the magnitude of the thermal gradient across the stack , thus making it possible to achieve the same order of performances within a smaller area of the collector. The influence of the main thermo-optical parameters has been acknowledged as well as a family of curves which provide the expected efficiency at BOL and EOL.