Closed Cycle Engine Program Used in Solar Dynamic Power Testing Effort

NASA Lewis Research Center is testing the world's first integrated solar dynamic power system in a simulated space environment. This system converts solar thermal energy into electrical energy by using a closed-cycle gas turbine and alternator. A NASA-developed analysis code called the Closed Cycle Engine Program (CCEP) has been used for both pretest predictions and posttest analysis of system performance.

The solar dynamic power system has a reflective concentrator that focuses solar thermal energy into a cavity receiver. The receiver is a heat exchanger that transfers the thermal power to a working fluid, an inert gas mixture of helium and xenon. The receiver also uses a phase-change material to store the thermal energy so that the system can continue producing power when there is no solar input power, such as when an Earth-orbiting satellite is in eclipse.

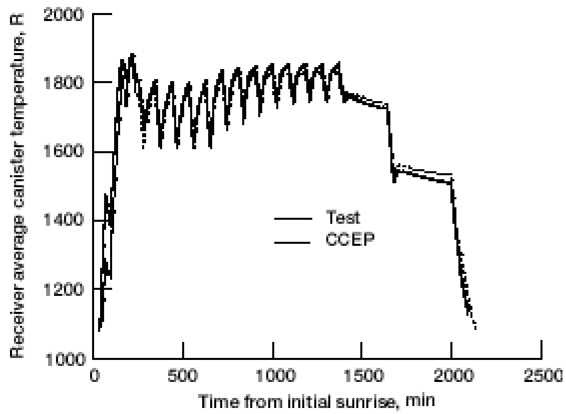
The system uses a recuperated closed Brayton cycle to convert thermal power to mechanical power. Heated gas from the receiver expands through a turbine that turns an alternator and a compressor. The system also includes a gas cooler and a radiator, which reject waste cycle heat, and a recuperator, a gas-to-gas heat exchanger that improves cycle efficiency by recovering thermal energy.

CCEP was adapted more than 15 years ago from the Navy/NASA Engine Program, a computer program written to design and analyze open-cycle aircraft engines and auxiliary systems. Modifications have included provision for closed-cycle analysis and addition of solar dynamic system components such as concentrators, receivers, and space radiators. More recently, CCEP's Fortran code has been updated and plotting capabilities have been added.

This program allows users to model all the components of a solar dynamic power system by using input data sets. Some components, such as turbomachinery, can be modeled with performance maps. Heat exchanger and radiator performance is based on input geometry and material property data. The code can be used to design new systems and analyze existing ones.

CCEP has been used in designing tests of the solar dynamic power system in Lewis' Tank 6, which provides a space thermal vacuum environment. Testing typically includes a heatup period followed by simulated orbital operations with sun/shade cycles. Predictions of cycle temperatures and output powers for an entire test run can be made on the basis of given test parameters, such as input solar power, engine speed, and coolant temperatures. During posttest analysis, key measured parameters are used to compare predicted performance with actual performance. Deviations from expected performance and sensitivities to testing conditions and component performance can be explored by varying appropriate CCEP input data.

Future testing of the solar dynamic system in Lewis' Tank 6 is planned to include the automatic system thermal management, where engine speed control is used to maintain receiver temperatures at acceptable levels. CCEP will be used in test design and posttest analysis.



Test data and CCEP simulation of receiver canister temperatures for startup, orbital operation, and steady-state operation. Receiver canisters contain a phase-change material for thermal energy storage.

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