BRAYTON MODULE DEVELOPMENT OVERVIEW

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Abstract

The Brayton module development effort has involved the solarization of existing gas turbines. At one time parallel developments were contemplated using both the Advanced Gas Turbine (AGT) and the Subatmospheric Brayton Cycle (SABC) engines. The AGT is being developed for automotive applications by the Garrett Turbine Engine Company (GTEC) under contract to DOE and NASA while the SABC has been developed for a gas-fired heat pump application by the AiResearch Manufacturing Company under contract to the Gas Research Institute (GRI). Funding limitations led to a single module development contract with Sanders Associates. In FY 1982 they conducted trade studies of the AGT, the SABC and other existing gas turbines in combinatiuon with various concentrators. The Sanders recommendation from these studies was to use the SABC for near-term module development while following the AGT development for later advanced application. Following JPL and DOE approval of this approach, Sanders completed a preliminary design at the module, and developmental subsystems are being completed.

Background

Brayton cycle (gas turbine) engines have been considered for solar thermal application because of the large existing experience base, the simplicity of the rotating assembly, demonstrated long life of gas turbines with foil bearings, the simple incorporation of a hybrid combustor with an air receiver, and the potential for high efficiency in high temperature ceramic engines.

The AGT is being developed for automotive application by GTEC under contract to DOE and NASA. In its final ceramic configuration, it will have the capability to produce more than 50 kW of shaft power at more than 40 percent efficiency with turbine inlet temperatures up to 2500°F. The development initially uses a lower efficiency metal engine with a ceramic regenerator at a turbine inlet temperature of 1600°F. This engine is undergoing development testing while the ceramic parts are being rig tested.

The SABC engine is being developed for gas-fired heat pump application by AiResearch under contract to GRI. This is a smaller, 8 kWe, partially closed cycle metal engine, operating at a turbine inlet temperature of 1600°F with the pressure through the turbine dropping from one (1) atmosphere to 0.4 atmospheres. This engine has all foil bearings and is readily amenable to the incorporation of a shaft mounted permanent magnet alternater (PMA) replacing the heat pump freon compressor.

When reduced DOE funding mandated a single Brayton module development, Sanders Associates, the system Contractor for the Brayton module development, conducted trade studies in FY 1982. These studies considered the AGT, SABC and other existing gas turbines in combination with several concentrators. The results of these studies were reported at the Fourth Annual Parabolic Dish Solar Thermal Power Program Review in December, 1982.

Recommendations Resulting From Trade Studies

The studies indicated potential for the AGT in its eventual, ceramic, high-temperature, high-efficiency development. However, the ceramic engine is several years from fruition, and additional changes such as incorporation of all foil bearings and a shaft-speed PMA will be needed to increase the 3500 hours of automative lifetime to the 50,000 hours desired for the solar program.

The SABC engine, has a lifetime goal of 50,000 - 100,000 hours for the heat pump program, and this is considered a realistic expectation based on engine test results to date and field experience with similar foil bearing units. Cost studies indicate that this engine can meet cost goals even at relatively low production levels of 1000 units per year. These factors show potential for a near term, cost effective application, even though the net efficiency of small, metal Brayton engine/generators is limited to 25 to 30 percent.

The studies identified several small concentrators which were a reasonable match for the 8 kWe engine. These included concentrators developed by PKI, Essco, SKI and LaJet. Tradeoffs on concentrator size have been undertaken in several studies with various results. Sanders identified lower unit weight and cost advantages for small concentrators together with the higher production level for a given power level.

Module Development Program

The FY 1983 Sanders preliminary design identified the following module subsystems:

1. AiResearch SABC (Mark IIIB) engine with permanent magnet alternator.

2. Sanders air receiver based on their High Temperature Solar Receiver (HTSR).

3. LaJet Energy Company LEC 460 concentrator.

4. Sanders system controls using Standard Microprocessor components.

5. Abacus inverter.

The module development will occur in two stages. In the first stage, developmental subsystems have been fabricated and are being prepared for development testing. These results will be used for design modifications with the subsystems for the final module available at the end of FY 1984.

The SABC Mark IIIA development engine has reduced power and efficiency capability as does the 5 kWe, load cell, PMA used in the development unit. However, this developmental engine/generator will allow development testing of combined subsystems and provide data for design modification and controls software development. Meanwhile an improved Mark IIIB engine with an integral shaft, full load PMA is being assembled.

The LaJet 460 concentrator is the fifth version of a multi-faceted membrane concentrator, privately developed by the LaJet Energy Company. Facet tests at JPL together with analyses have indicated the suitability of this concentrator for the presently designed 10 inch receiver aperture. The concentrator already comes close to meeting cost goals in production quantities.

Future Expectations

The Sanders Brayton module using the AiResearch SABC engine/generator and the LaJet Concentrator appears to provide a realistic near-term Brayton module. Following module verification testing in early FY 1985, this technology is expected to be ready for a multi-module field experiment or for field application.

Meanwhile, the AGT automotive program is being monitored with the ceramic version of this engine is expected to provide an advanced Brayton alternative. A solar feasibility test on the reduced performance metal SAGT may occur in FY 1984 with possible readiness of a ceramic SAGT module in FY 1986.