ASSESSMENT OF TRIFLUOROMETHANE SULFONIC ACID (TFMSA) AND PHOSPHORIC ACID FUEL CELLS (PAFC) FOR VEHICULAR POWER PLANTS

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The purpose of this program was to provide the information necessary to critically assess the technical and economic viability of a vehicular power plant based on TFMSA and PAFC fuel cell studies.

Performance characteristics of PA and TFMSA fuel cells were projected based on Energy Research Corporation experimental data. The performance of the PAFC at the design current density of 300 mA/cm^2 was 0.714 V. The performance of the TFMSA fuel cell at the same current density was 58 mV higher than the PAFC.

A parametric analysis was conducted to examine the effects of current density and catalyst loading on system efficiency (expressed as mpg of methanol) and cost. The system considered was a 20-kW fuel cell power plant for a basic mid-sized automobile (*i.e.*, a General Motors X car). An operating current density of 300 mA/cm^2 and a catalyst loading of 0.375 mg/cm^2 were selected for conceptual design. Most of the savings in system cost were gained at these conditions without any large penalty in fuel economy.

Operating conditions of 3.16 atm and 90 °C were chosen for the TFMSA fuel cell to control acid concentration at 6 M. A high acid conductivity and a low acid loss can be obtained without flooding the electrodes at this concentration. Operating conditions for the PAFC were selected as 3 atm and 190 °C. Most of the performance gain by pressurization was obtained at 3 atm.

A fuel economy of 25 mpg of methanol (urban driving schedule) and a power plant cost of $1900 were computed for the TFMSA fuel cell power plant. The fuel consumption in startup was assumed negligible because of almost instant start. For the PAFC, the startup fuel consumption was estimated to be 20 percent of the total fuel consumption. A net fuel economy of 22 mpg of methanol and an initial cost of $2000 were predicted for the PAFC power plant.

Fuel cell bipolar plates were of the ‘Z pattern’ design. In this type of fuel cell stack, the cooling air and the chemical air have separate flow passages. In a DIGAS stack, a part of the cathode exhaust (lean in oxygen) is recycled and mixed with makeup air before entering the cathode. This reduces the oxygen concentration at the cathode. As a result, in the Z plate stack, the oxygen concentration at the cathode is higher than in the DIGAS stack. This increases the cell performance by 22 mV.

Estimates of size and cost of the two power plants were similar. Weight, volume, and manufacturing cost of the power plants on a kW basis were as follows:

- 24 to 25 lb/kW;
- 0.80 to 0.92 ft^3/kW, using a packing factor of 0.5; and
- $95 to $100/kW, assuming a mass production of 100 000 units/yr.

The LANL guidelines for weight (less than 700 lbs) and volume (less than 12 ft^3) of the 20-kW passenger car power plant were satisfied by both of the power plants.

Both conventional reforming and partial oxidation/reforming fuel processing options were considered. Both approaches were found to be feasible although system efficiency was lower for the partial oxidation option.

The peak power of the PAFC power plant was 61 kW. The peak power of the TFMSA fuel cell power plant was 10 kW higher than that of the PAFC. The pressurized reformer had a sufficient inventory of reformed gas to support this peak power of 71 kW for 0.7 s.

Because of the similarity of the results for the two power plants and the immaturity of the TFMSA technology, no effort is planned for TFMSA fuel cells in 1983. Plans for the PAFC are described in the "Assessment of Phosphoric Acid Fuel Cells for Vehicular Power Systems" summary.

Recent publications

1 Assessment of trifluoromethane sulfonic acid and phosphoric acid fuel cells for vehicular power plants, Energy Research Corporation, *Final Report, Contract No. 4-L61-3861 V-1*, Los Alamos National Laboratory, December 1981.

ASSESSMENT OF SOLID POLYMER ELECTROLYTE (SPE) FUEL CELLS FOR VEHICULAR POWER PLANTS

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The purpose of this program was to provide the information necessary to critically assess the technical and economic viability of a vehicular power plant based on an SPE fuel cell stack.

The power plant system was required to use methanol as the fuel and air as the oxidant. Physical and electrical power plant requirements for providing suitable performance in a compact passenger car were established by LANL.

A baseline SPE power plant system was designed. This system is perhaps not the optimum configuration, but it does serve to indicate the possible capabilities of the SPE power plant. As shown in Table 1, the baseline power plant system design easily meets the volume and weight requirements. The power and voltage characteristics match those specified.

The following are major features of the baseline SPE power plant system.