

50-KILOWATT AMBIENT PRESSURE AUTOMOTIVE PEM FUEL CELL AND DIRECT METHANOL FUEL CELL DEVELOPMENT

*Michael E. Gorman and Thomas F. Fuller
International Fuel Cells
South Windsor, CT 06074*

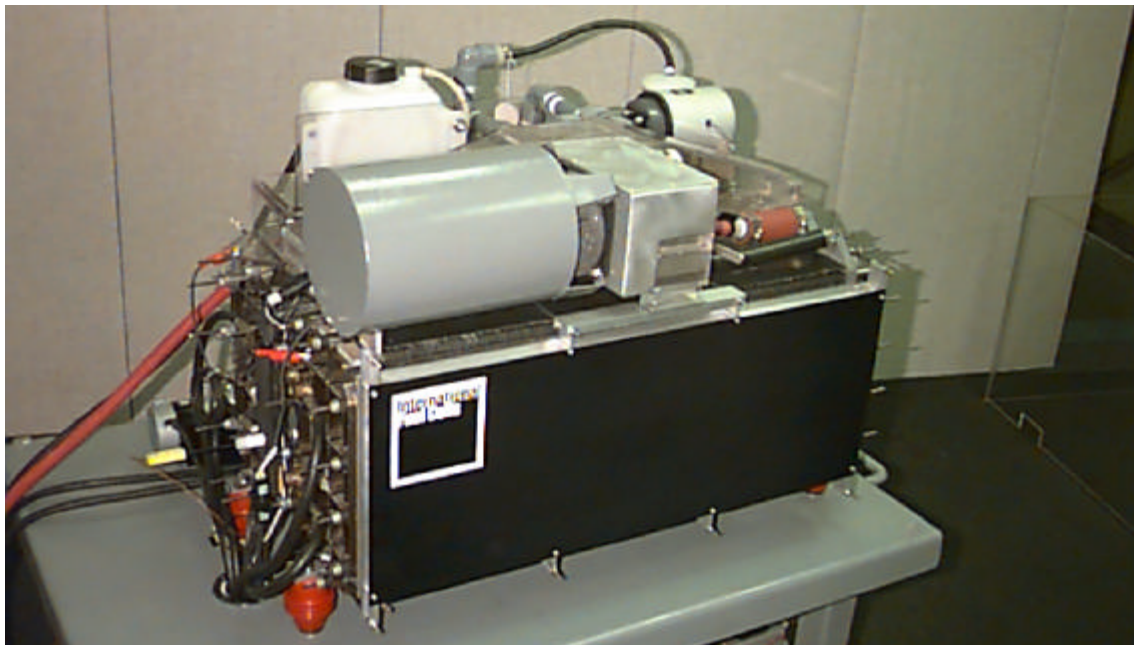
October 27, 1997

High-Performance, Ambient Pressure 50-kW

Objective. - The objective of this work is the development of a high-performance compact PEM fuel cell power plant that operates at or near-ambient pressure. By operating at or near-ambient pressure, the limitations of conventional high pressure PEM power plants are eliminated. These include the high pressure compressor itself, its efficiency penalties, particularly at cruise power, transient response and the need for a more robust and costly design for plumbing, components and the stack itself. In

short, the ambient pressure power plant that achieves the same electrochemical performance as a high pressure power plant has a cost, weight, volume, efficiency and durability prospectus that is superior to high pressure designs.

Program Results. - IFC's power plant that achieves these goals is shown in Figure 1. It is designated PC29. It requires no compressor or turbo machinery and is competitive across the board with high pressure power plants. It is a prototype power plant intended to demonstrate the advantages of an ambient-pressure power plant to vehicle manufacturers.



D000102

Figure 1. IFC's PC29 50 kW Power Plant

The PC29 has a continuous output rating of 50 kW net at a delivery voltage of 255 volts. It weighs 310 pounds (141 kilograms) and occupies 8.7 cubic feet (235 liters). Its specific weight and volume are 6.2 lb/net kW (3.0 kg/kW) and 0.18 ft³/net kW (4.7 liters/kW) respectively. Its efficiency at 50 kW output is 50 percent and approaches 60 percent in the cruise power range of 10-20 kW. These efficiencies include all power required to run the power plant's components, air blower, pumps, controls, etc.

The power plant weight and volume includes all accessories, plumbing and instrumentation necessary for operation in a vehicle, except for a twelve-volt starting battery and radiator for cooling. The power plant operating pressure on both the hydrogen and air electrodes is 1.0 psig or less.

The PC29 incorporates technology wholly owned by IFC. As shown in Figure 1, it was developed into a power plant under a contract from the Ford Motor company, sponsored by the United States Department of Energy.

Power Plant Growth Capability

The design for the PC29 was frozen in January 1997. IFC's continuing investment in this technology has significantly improved it since January and continues to improve it at a rapid rate. Based on our most recent research results, we can project a power plant design with a specific weight of 3 lb/kW (1.4 kg/kW) and a specific volume under 0.1 ft³/kW (2.5 liters/kW).

Direct Methanol Fuel Cell Program

Objectives. - The objectives of this research and development program is to advance the performance and viability of direct methanol fuel cells. For fuel cells to be an attractive alternative to conventional automotive power plants, the fuel cell stack combined with the fuel processor and ancillary systems must be

competitive in terms of both performance and costs. A major advantage for the direct methanol fuel cell is that a fuel processor is not required.

The major limitations for direct methanol fuel cells are (1) methanol crossover from the anode to the cathode across the membrane separator, (2) high polarization of the anode for oxidation of methanol, and (3) systems design.

Membranes. - Three approaches to reducing the methanol crossover across the membrane have been investigated. The first (R. Moore, University of Southern Mississippi) incorporates another polymer into Nafion. The second (R. Kunz, University of Connecticut) involves composite membranes of Nafion. In the third approach, (J. Leddy, University of Iowa) the surface of Nafion is coated with a second polymer.

The methanol crossover has been reduced by 30 to 50 percent. In general, the resistance of the membrane increases as the methanol crossover decreases. However, in some of the tests, the methanol crossover has been reduced with a minimal increase in membrane resistance.

Catalysts. - A number of binary and ternary anode catalysts were prepared and evaluated in half-cell and full cells. The catalysts evaluated included Pt/Ta, Pt/Ru, Pt/Pd, and Pt/Ru/Ir. Pt/Ru gave the best overall performance under fuel cell conditions. The performance of the Pt/Ru/Ir catalyst was nearly as good. Although, the BET surface area of the Pt/Ru/Ir catalyst was lower. When corrected for surface area, the Pt/Ru/Ir catalyst was superior.

Several alloy cathode catalysts were also evaluated. These materials were supported on carbon. Compared to platinum, the oxygen reduction activity of the alloys was demonstrated to be better in both half-cell and H₂/air fuel cells. Optimization of these catalysts with direct methanol fuel cells is still in progress and may require that the crossover be reduced fur-

ther before the advantages of these catalysts can be used.

Performance analysis and design. - The direct methanol fuel cell stack and systems technology is less advanced than other fuel cell technologies, e.g., H₂/air PEM technology. There are several systems issues that need to be resolved to develop an efficient, cost effective direct methanol oxidation system. These include: 1) optimization of the methanol feed system, 2) evaluation and selection of the cell stack operating condition that provides the best

trade-off between system complexity and overall system performance, and 3) optimization for weight and volume.

Design criteria are established for a 50 kW power plant for light-duty transportation applications. A conceptual design for the power plant has been made. Further, a detailed comparison of the specific power and efficiency of the direct methanol fuel cell system is made. This serves to identify development goals and direct future research and development.