ENERGY EFFICIENCY AND RENEWABLE ENERGY

OFFICE OF TRANSPORTATION TECHNOLOGIES

Transportation FOR THE 21ST CENTURY

Carbon/Carbon Composite Material Lowers Cost of Bipolar Plates for PEM Fuel Cells

Background

The significant and growing interest in fuel cells for transportation and stationary applications has been demonstrated by the attention the technology has received from both government and industry. In particular, research for vehicular applications has focused on the Proton Exchange Membrane, also known as the Polymer Electrolyte Membrane, or PEM, fuel cell. PEM fuel cells are of special interest to the automotive industry because of their potential for good power density and the low-temperature operation of the fuel cell stack. Challenges, however, include reducing the weight, volume, and cost of the fuel cell stack with the current goal being to develop a 50-kW stack system weighing less than 133 kg at a volume of no more than 133 liters and a cost of $35/kW.

A key component of the PEM fuel cell is the bipolar plate that separates individual cells in the stack and provides channels for hydrogen and air flow. Most PEM fuel cells have until now used high-density graphite as the material of choice from which to machine bipolar separator plates. High-density graphite has the desired electrical, chemical, and physical properties, but material and machining costs are prohibitively high. Graphite plates are also too heavy and too brittle for use in automobiles. The requirements for a bipolar plate include low-cost materials and processing leading to an overall cost of no more than $10/kW. Other requirements are minimal weight, a thickness of less than 3 mm, sufficient mechanical integrity, high surface and bulk electrical conductivity, low permeability (boundary between fuel and oxidant), and resistance to corrosion in the moist atmosphere of the fuel cell. Finding less expensive materials and simplifying the manufacturing process will be necessary if the PEM fuel cell is to achieve widespread acceptance by automobile manufacturers.

The Technology

Scientists at Oak Ridge National Laboraory have succeeded in fabricating a carbon/carbon-composite bipolar plate by slurry molding a chopped-fiber preform and then sealing it with chemically vapor-infiltrated carbon. The slurry-molding process produces an isotropic material containing a phenolic binder to enhance strength and geometric stability.

Because a fuel cell consists of stacks of bipolar plates with membrane electrode assemblies (MEAs) between, the porous plate surfaces must be sealed to prevent leakage of hydrogen and oxygen from one cell to another. The surface of the preform is therefore sealed using a chemical vapor infiltration (CVI) technique in which methane is flowed over the plate at high temperature to deposit carbon on the near-surface material. This creates a hermetic seal and a continuous, high-conductivity medium.

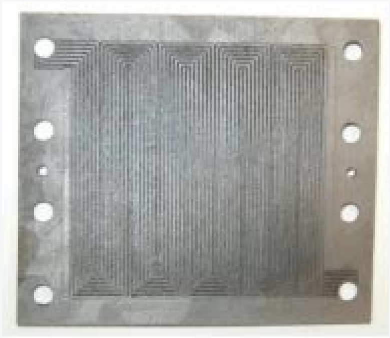
Oak Ridge has demonstrated that not only can carbon-fiber composite plates be made to perform as well as graphite but are also half as heavy, may cost one-fifth as much to produce, are more conductive and corrosion resistant, and are easier to manufacture. Although the earliest carbon-composite bipolar plates developed at Oak Ridge were fabricated with flow fields for fuel and oxygen machined into the plate, researchers have also successfully demonstrated the impression of these features into the preform material using brass molds, another essential step in reducing the production costs of this enabling technology for fuel cell systems.

Commercialization

Porvair Fuel Cell Technology (Hendersonville, NC) has licensed the technology for making carbon/carbon composite bipolar plates from Oak Ridge. The method of fabrication lends itself to various means of high-volume production, including semi-batch and continuous (as in paper-making), thereby lowering manufacturing costs. In a project co-funded by DOE, Porvair intends to invest approximately $6M over the next three years to scale up the process and to build a production line capable of producing about 300 parts per hour. Porvair expects to be able to begin providing samples to interested fuel cell producers by the end of 2001.

Benefits

- **Slurry-molded fabrication of carbon/carbon composite material lends itself to low-cost, high-volume production**
- **Hydrogen/oxygen flowfields can be stamped into the carbon composite preform**
- **Increased conductivity, lighter weight, and greater corrosion resistance than graphite plates**



This carbon/carbon composite bipolar plate developed at Oak Ridge National Laboratory may significantly lower the cost of PEM fuel cells.

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