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NASA TECH BRIEF

Marshall Space Flight Center

Fuel-Cell Heat and Mass Plate

A fuel-cell system requires that the temperature and the amount of water in the system be controlled. Rather than regulate these by external systems, it is preferable to save weight and reduce complexity by making the system self-controlled.

A heat and mass plate that serves as a heat pipe can be built into the cell to control the temperature and the water inventory. The plate consists of a matrix, filled with liquid water, and a space, filled with water vapor. Both the matrix and the space extend beyond the fuel-cell stack, so that heat and water may be removed as necessary.

The side of the matrix opposite the space faces the reaction chamber, where water is produced electrochemically. Heat is removed as the heat of vaporization of water. Water evaporates from the matrix on the side of the space where the partial pressure is less than on the reactant side. The water vapor moves through the vapor space to outside the cell stack, where it condenses on the matrix to release the heat of vaporization. Water condensed on the matrix is then drawn back into the cell by capillary action.

The vapor space is kept at a controlled pressure by venting it to the atmosphere. This pressure determines the boiling point of the water and, thus, the temperature of the matrix surface. The temperature of the electrodes likewise is controlled, because they are close to the matrix.

The performance of the heat and mass plate may be enhanced by keeping the liquid/water-vapor interface exactly in the plane where the matrix meets the water-vapor space. This can be done by adjusting the boiling point in the matrix or by controlling the venting, in one of the following ways:

a. A matrix with an ion-exchange capacity may be used. The concentration of ions in the water, in the matrix, will elevate its boiling point.
b. Ions (e.g., K^+ or OH^-) can be included in the matrix solution, thus raising the boiling point of the water there.
c. The vapor space can be kept at a higher pressure than the liquid in the matrix. With a small-pore matrix, the local radius of curvature of the interface will increase the temperature required to evaporate water from the matrix.
d. Two discontinuous metal strips can be deposited on the vapor side of the matrix, and the conductivity between them can be measured. The vent valve then would be opened only when the conductivity is above a specified value:

Notes:

1. The development of a fuel-cell system is further described in the following NASA Tech Briefs:
   B73-10475, Vapor-Deposited Platinum as a Fuel-Cell Catalyst
   B73-10472, A Methanol/Air Fuel-Cell System
   B73-10473, An Electrochemical Engine
2. Requests for further information may be directed to:
   Technology Utilization Officer
   Marshall Space Flight Center
   Code A&PS-TU
   Marshall Space Flight Center, Alabama 35812
   Reference: B73-10489

Patent status:

NASA has decided not to apply for a patent.

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