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PEM fuel cell magnesium sea water power supply

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PEM fuel cells for the power range between 1 and 20 W were developed and optimized for safe passive air breathing operation and low production costs. Dry out of membrane and thus impedance rise is prevented due to micro holes inside the current collectors and the resulting water concentration gradients. Metal foil current collectors are double used as cooling fins and large cathode air channels provoke free air convection. These fuel cells were combined with a sea water based hydrogen generator for maritime power supply applications.

The environmentally friendly magnesium fuel cell system uses seawater electrolyte and atmospheric oxygen and was tested under practical considerations. The hydrogen rate and therefore the power density of the system were increased by a factor of two by using hydrogen evolution cathodes with a gas separation membrane instead of submerged cathodes without gas separation. Commercial magnesium AZ31 rolled sheet anodes can be dissolved in seawater for hydrogen production, down to a thickness below 100 µm thickness, resulting in hydrogen generation efficiency of the anode of over 80 %. A practical specific energy / energy density of the alloy of more than 1200 Wh/kg / 3000 Wh/l were achieved when coupled with the fuel cell with atmospheric air breathing cathode. The performance of several AZ31 alloy anodes was tested as well as the influence of temperature, electrolyte concentration and anode – cathode separation of the hydrogen generation cell. The excess hydrogen produced by the magnesium hydrogen evolving cell, due to the negative difference effect which is a characteristic for magnesium anodes in aqueous electrolyte, is proportional to the cell current in case of the AZ31 alloys, which simplifies system control considerably. Stable long-term operation of the system was demonstrated at low pressures which can be maintained in an open-seawater-submerged hydrogen generator.

Keywords: PEM fuel cell, passive operation, Mg anode, hydrogen generation, sea water electrolyte

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