SPACE POWER SYMPOSIUM (C3)
Space Power Technologies and Techniques (2)

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AIR-INDEPENDENT FUEL CELL POWER SYSTEM FOR SPACE APPLICATIONS

Abstract

An air-independent propulsion (AIP) system based on fuel cell technologies was developed for space applications in the present study. The fuel cells for NASA's Gemini, Apollo, and Space Shuttle programs carried cryogenic liquid oxygen as the oxidizer. The liquid oxygen invariably evaporates over a few weeks, limiting the mission duration. Hydrogen that is a fuel for the fuel cell is often stored cryogenically. This approach, however, is not suitable to space applications due to the limited mission time caused by the exceptionally high boiling-off rate of liquid hydrogen. Hydrogen peroxide was selected as an oxidizer for space power application where air independence is a must in the present study. Catalytic decomposition of hydrogen peroxide was used to generate oxygen and water. The pure oxygen was provided to a fuel cell and the water was stored separately. Sodium borohydride in the solid state was used as a hydrogen source in the present study. Pure hydrogen can be generated by a catalytic hydrolysis reaction in which the water source was obtained from the hydrogen peroxide decomposition. Solid storage of hydrogen has a high energy density increasing the mission time and does not suffer from the problem of cryogenic hydrogen. A fuel cell system was fabricated to validate the fuel cell based air-independent power system proposed in the present study. Two catalytic reactors were prepared; one is for decomposition reaction of hydrogen peroxide and the other is for hydrolysis reaction of sodium borohydride. Platinum and cobalt metal catalysts were synthesized for the reactions, respectively. The fuel cell system was evaluated in a vacuum chamber for space environment.