Emerging Fuel Cell Technology Being Developed--Offers Many Benefits to Air Vehicles

Fuel cells, which have recently received considerable attention for terrestrial applications ranging from automobiles to stationary power generation, may enable new aerospace missions as well as offer fuel savings, quiet operations, and reduced emissions for current and future aircraft. NASA has extensive experience with fuel cells, having used them on manned space flight systems over four decades. Consequently, the NASA Glenn Research Center has initiated an effort to investigate and develop fuel cell technologies for multiple aerospace applications.

Two promising fuel cell types are the proton exchange membrane (PEM) and solid oxide fuel cell (SOFC). PEM technology, first used on the Gemini spacecraft in the sixties, remained unutilized thereafter until the automotive industry recently recognized the potential. PEM fuel cells are low-temperature devices offering quick startup time but requiring relatively pure hydrogen fuel. In contrast, SOFCs operate at high temperatures and tolerate higher levels of impurities. This flexibility allows SOFCs to use hydrocarbon fuels, which is an important factor considering our current liquid petroleum infrastructure. However, depending on the specific application, either PEM or SOFC can be attractive.

As only NASA can, the Agency is pursuing fuel cell technology for civil uninhabited aerial vehicles (UAVs) because it offers enhanced scientific capabilities, including enabling high-altitude, long-endurance missions. The NASA Helios aircraft demonstrated altitudes approaching 100,000 ft using solar power in 2001, and future plans include the development of a regenerative PEM fuel cell to provide nighttime power. Unique to NASA's mission, the high-altitude aircraft application requires the PEM fuel cell to operate on pure oxygen, instead of the air typical of terrestrial applications.

Fuel cells may also benefit conventional UAVs by providing greater power for payload and/or emergency backup. Adding power to current UAV platforms used for Earth science missions would allow more instrumentation, higher data-scan rates, and higher data-transmission rates to enhance scientific missions. Both PEM and SOFC are potential candidates, with SOFC offering the advantage of utilizing a single, conventional liquid fuel.

In addition, NASA is pursuing fuel cell technology for aircraft power generation on commercial transports. Power for systems necessary to fly the aircraft and accommodate passengers traditionally relies on auxiliary power units and power extracted from the main engines. Future commercial aircraft will incorporate more electric aircraft architectures and will use fuel cells. Challenges remain, however, to successfully apply the technology to commercial flight systems. Fuel processing is critical because the commercial transportation sector will depend on hydrocarbon fuel for the foreseeable future. High-

temperature SOFCs are best suited because of the similarity in operating temperature with the fuel reformation process, and they enable hybrid configurations (SOFC and turboalternator) to increase efficiency. There are other challenges with unique aircraft requirements: improving the specific power of the stack, reducing the weight of the remaining components, and investigating flight-operation conditions.

Realizing the full benefits of fuel cells for aerospace applications will require a collaborative effort. Through workshops and technical/programmatic interchanges, Glenn has begun to facilitate and foster the required national partnership with the Department of Energy, the Department of Defense, State governments, academia, and the aerospace and fuel cell industries.

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