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Flame-Assisted Solid Oxide Fuel Cell for Hybrid Gas Turbine Power Generation

Background

An aircraft's auxiliary power unit (APU) provides electrical and pneumatic power for such functions as lighting, ice clearing, engine starting, and cabin air conditioning. The use of dual chamber solid oxide fuel cells (DC-SOFCs) increases efficiency and reduces NOx emissions, but results in lower power densities compared to conventional propulsion methods. For this reason, gas turbine SOFC hybrid systems offer a more balanced solution. However, DC-SOFCs contend with limited fuel flexibility, low thermal endurance, and sealant failure. As an alternative, direct flame fuel cells (DFFCs) have been developed, which place fuel cells directly over an open flame which eliminates the need for separate chambers and reduces system weight. Still, DFFCs are characterized by inconsistent power densities and low fuel utilization which lead to temperature fluctuations near the fuel cell stack. Therefore, a new gas turbine SOFC hybrid system that addresses these shortcomings will improve overall efficiency.

Invention Description

Researchers at Arizona State University have developed a new gas turbine SOFC hybrid system that integrates a flame-assisted fuel cell (FFC) for improved thermal management and fuel cell conversion efficiency. The FFC design consists of a two-stage combustion process: in the first stage, fuel-rich combustion produces syngas for generation of electrochemical power from the SOFC, and in the second stage, fuel-lean combustion then burns any remaining unreacted fuel. The heat generated during the two-stage combustion process can be used for a number of internal process including the maintenance of fuel cell temperature, and preheating of fuel and air. The syngas composition for fuel-rich combustion is studied using chemical equilibrium analysis of Jet-A/air at 8 Bar and 1073 K. The results show the potential for reforming Jet-A fuel to 22% carbon monoxide and 18% hydrogen in the exhaust at an equivalence ratio of 2.4.

Potential Applications

- Aircraft auxiliary power units (APUs)
- Gas turbine solid oxide fuel cell (SOFC) hybrid power generators

Benefits and Advantages

- Increased efficiency translates to decreased NOx emissions
- Operates without a fuel reformer, resulting in reduced weight and reduced complexity
- Compatible with Jet-A fuel
- Manages temperatures by passing cooling air over fuel-rich combustion stage

Related Publication

Homepage of Professor Ryan Milcarek