Mechanical Engineering Thesis Defense

Exploring Solid Oxide Fuel Cell Integrated in the Exhaust Gases of a Fuel-rich Diesel Fuel Engine

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Abstract

A concept for integration of flame-assisted fuel cells with a diesel engine is described in this work. Exhaust gases from the fuel-rich combustion of diesel fuel with air are fed into the solid oxide fuel cell (SOFC) anode for generation of electrical power. The exhaust gas composition is analyzed at equivalence ratios ranging from 1.0 – 5.0. The combined power efficiency of the system increases until an equivalence ratio of 2.6 and decreases thereafter. This is due to the lower concentration of hydrogen in the exhaust at higher equivalence ratios. The highest SOFC electrical efficiency is 36.1% at an equivalence ratio of 2.6, a fuel utilization of 90% and operating voltage of 0.7V. The combined system showed a maximum change in efficiency of 378% at an equivalence ratio of 3.2, with a power generation of 219.9kW as compared to a diesel engine without a SOFC under the same conditions. The Diesel cycles are analyzed on P-V and T-S diagrams. The thermodynamic cycle analysis verifies energy conservation. A sensitivity analysis is conducted to assess the impact of fuel utilization on the system performance. The combined SOFC and diesel engine system is also analyzed with dual fuel combustion, where hydrogen is substituted in place of up to 30 mol% diesel fuel. Similar predictions were found out, showing an increase in thermal power efficiency near an equivalence ratio of 3.0.

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