

On the Efficiency of Automotive H₂/O₂ PE Fuel Cell Systems

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Abstract

Efficiency is the key argument for the application of polymer electrolyte fuel cells in automotive applications. Efficiency of the fuel cell system depends on a number of interdependent parameters. These are on the one hand the properties of the electrochemical components as well as the chosen operating conditions. On the other hand efficiency of the complete system also strongly depends on the characteristics of the balance of plant components (BoP).

The use of pure oxygen reduces the ORR over-voltage, as the oxygen partial pressure can easily be increased from typically 0.4 bar by an order of magnitude. Membrane conductivity is easier maximized with the reduced volume flow at the cathode and higher possible gas pressures. The use of pure oxygen also eliminates the need for an air compressor, the main parasitic power consumer in the BoP.

In conventional automotive systems, typically 15 – 20% of the stack power is lost for the operation of the BoP, the main power consumer being the air compressor. Typical tank to electric power efficiencies are in the order of 45%. The use of pure oxygen as the oxidant increases on the one hand the cell efficiency at the same current density and requires greatly reduced BoP parasitic power. At similar operation points, therefore the tank to electric power efficiency increases by about 20%.

Introduction

It seems probable, that future production of hydrogen will go through routes of water splitting either by electrolysis or thermochemical pathways. Pure oxygen will be a byproduct of those hydrogen generation processes. This opens up the possibility to use pure oxygen instead of air for the conversion of hydrogen to electricity in fuel cells. This paper investigates the use of pure oxygen on the overall fuel cell system efficiency for the automotive application as compared to air, including the energetic cost for the production of oxygen.

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Mohamed N. Rahaman



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