DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD Public Defence

Title:	Operational Strategies for longer Durability of HTPEM Fuel Cells Operating on Reformed Methanol
Location:	Pontoppidanstræde 111, auditorium
Time:	Thursday 8 March at 13.00
PhD defendant:	Sobi Thomas
Supervisor:	Professor Søren K. Kær
Moderator:	Associate Professor Mads Pagh Nielsen
Opponents:	Associate Professor Erik Schaltz, Dept. of Energy Technology, Aalborg University (Chairman) Professor Jens Oluf Jensen, Department of Energy Conversion and Storage, DTU Professor Werner Lehnert, Institute for Energy and Climate Research, RWTH Aachen University

All are welcome. The defence will be in English.

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Abstract:

Fuel cells are expected to play a key role in meeting the energy goals of many countries including Denmark. However, to be a feasible option for the largescale adoption, the lifetime of fuel cell system needs to be improved and the cost of production needs to come down at the same time. To meet these requirements different paths, need to be investigated. There is a lot of focus on reducing the cost of materials used in fuel cell systems and on improving the reliability and the durability. Another approach is to develop a proper operational strategy, which could ensure reduced production cost and better durability, thereby ensuring a large-scale availability of fuel cell systems.

In this dissertation, different operational strategies are investigated to improve the durability as well as reduce the production cost by proposing easier activation of high temperature polymer electrolyte membrane fuel cell (HT-PEMFC). The study focuses on reformed methanol high temperature PEMFC. Among many, one of the issues associated with the reformed methanol fuel cells are the residual or unconverted methanol vapour and partially converted carbon monoxide (CO) which may enter the fuel cell during operation. The composition of these residuals is dependent on the reformer temperature, where lower temperature results in a higher methanol slip, while a higher temperature results in higher CO slip. Therefore, the effect of different compositions of methanol vapour in the anode compartment of a single HT-PEMFC fuel cell system are analyzed. The results suggest integration of methanol reformer operating at lower temperature (200 ^{0}C) with an HT- PEMFC stack has no or minimal effect on the performance with methanol percentages of less than 3 %.

In another work, the break-in was carried out with 2 % methanol in the feed and compared to a cell whose break-in was carried out with pure hydrogen. The results show minimal effect in performance during break-in. However, the long-term operation shows faster degradation compared to the cell
operated with reformed fuel after a break-in with pure hydrogen. Therefore, it suggests it is not possible with the present strategy as discussed in the dissertation to avoid break-in with pure hydrogen.

Another major problem associated with HT-PEMFC is the acid redistribution of phosphoric acid in HT-PEMFC. The acid migration may result from different operating conditions, such as high current density operation acid doping level, temperature, product water, gas flow rates etc. Thus, test was carried out to determine how the hydrogen mass transport is affected by migration of acid towards the anode at high current density and the different time constants for the acid flooding and de-flooding were calculated. The time constant for acid flooding and de-flooding under the applied experimental conditions were 8 and 4 min respectively. The experiments were extended for lower doping levels and the results obtained were quite different as the acid flooding (high current density operation) and de-flooding (low current density operation) reported were reversed. At high current density the hydrogen mass transport resistance decreased and increased at low current density. This suggests that a doping level of (10-12 mgH3PO4/cm2) is optimal to avoid flooding of GDL and flow field at high current densities. This could be due to the capillary pressure not being high enough to force the acid to the GDL pores. However, the long duration tests are required to understand the long-term implications which is beyond the scope of this project.

The next step was to develop an operational strategy to avoid acid redistribution induced degradation on HT-PEMFCs. This could be achieved by operating the cell under load cycling profile. The results show that the degradation after 2000 h, with a time constant of 2 min at low current density (0.2 A/cm^2) the degradation was 36 µV/h which is lower compared to 57 µV/h for constant current density (0.55 A/cm^2) under the same operating conditions.