Analysing the effects of Oxygen diffusion on a HT PEMFC Stack Performance

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1. Introduction

• High temperature proton exchange membrane fuel cells (HT PEMFCs) which can be operated in the temperature range between 150°C and 200°C have drawn significant attention during the current decade. This is due to the fact that HT PEMFCs can be easily coupled to reformers which produce hydrogen (H₂) rich gases as opposed to the LT PEMFCs which are operated up to about 80°C. HT PEMFCs can tolerate carbon monoxide (CO) concentrations in the % range and there exists a possibility to recycle the heat generated in the fuel cell stack to the other system components such as metal hydrides, evaporators and the like. Further, they can be operated with low or almost no fuel gas humidification, thus offering a possibility to reduce the peripheral parts.

2. Measured performance curves of a HT PEMFC at 150°C – 180°C

• Measured current voltage curves of a HT PEMFC operating at 150°C – 180°C are depicted in Fig.1.

3. EIS tests results of a single cell operated at 170°C

• EIS (Electrochemical Impedance Spectroscopy) was employed to understand HT PEMFC stack performance under different conditions of Oxygen diffusion into reaction sites. Poor oxygen dissolution and diffusion and its subsequent impact on poor cathode kinetics has to be addressed to achieve satisfactory performance.

4. Equivalent Circuit Models used to analyse the EIS test results

• It has also been observed that the oxygen diffusion into the reaction sites is a function of temperature. While the EIS test results shown in Fig.3, the non-charge transfer resistance values were evaluated and are presented in Fig.6 as a comparison. It can be seen that the reciprocal of Rchem increases when the stack was operated with H₂/O₂, whereas the same exhibits a different trend when operated with Air.

5. Performance characteristics of a 5 Cell Stack at 170°C

6. EIS test results: 5 Cell Stack operated at 170°C (comparing the effects of Oxygen and Air)

7. Analysis of EIS results: A closer look at Rchem

• As explained earlier, the non-charge transfer resistance, Rchem could be attributed to the resistance to oxygen diffusion. After fitting the EIS test results into the equivalent circuits shown in Fig.3, the non-charge transfer resistance values were evaluated and are presented in Fig.6 as a comparison. It can be seen that the reciprocal of Rchem increases when the stack was operated with H₂/O₂, whereas the same exhibits a different trend when operated with Air.

8. Conclusions

• Oxygen diffusion (caused due to dissolution and diffusion) into the reaction sites should be improved to achieve satisfactory cell performance. Flow field design, stack operating regimes, should be carefully designed to achieve better oxygen diffusion.

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