Project Report 2036

Operate SOFC with Bio-Gas

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Objectives: short, medium and long term

The test required by HTCeramix is a duration test using toluene as a contaminant in a bio-syngas gas matrix. By bio-syngas is the syngas obtained by gasification of biomass. The operation of SOFC with syngas strongly increases efficiencies of internal combustion engines (ICE) that are nowadays used coupled with this technology. In addition ICE operation requires a strong clean-up of hydrocarbon volatile (TAR) that are present in the gas stream and that in case of condensation can damage the engine. In SOFC TARs can react in the cell and generate additional energy. On the long term, the objective is the development of a system based on biomass gasification and SOFC. On the medium term, a study has to be performed both on gasification system and on SOFC to evaluate boundary conditions for a correct integration. In details, gasification product has to be treated and cleaned, in order to be used in the SOFC. Yet, this introduces performance losses and system complexity. How deep and costly the cleaning has to be strongly depends on SOFC tolerance to gas impurities, in particular TAR content. The medium objective is to map the effect of TAR contaminant on SOFC technology. This specific project was focusing the study on the effect of one contaminant, toluene, in a single cell. The short objective was then to evaluate performance decay of a single SOFC commercial cell when fed with a simulated bio-syngas composition and toluene as contaminant.

Brief summary of work carried out

In accordance with the User the test conditions were indicated as follows: - Gas composition: H2 15%, CO 20%, CO2 10 %, N2 53 %, CH4 2 %; - Total flow (dry): 214 ml/min - Toluene: 10 g/Nm3 - Total time: 500h - Polarization condition: 500 mA/cm2 Toluene was added to the dry flow via a second line, where part of the N2 was sent to a bottle containing the liquid contaminant. Antoine's Law was used to control toluene quantity in the gas flow. This technique was preliminary validated with a specific test. In addition, the weight of the liquid was measured before and after the test to verify the total amount of contaminant sent to the cell. To perform the test, a preliminary start-up and characterization of the cell was performed. The aim of the test was to evaluate degradation with 4 different techniques: voltage measurement, polarization curve, wavelets, impedance spectroscopy (EIS). While voltage measurement was realized during the all test with 1Hz sampling frequency, polarization, wavelets and EIS were performed at the beginning of the test and every 100h. The cell was finally disassembled and analyzed via SEM.

Main achievements intended for publication

The cell operated for 500 h with no failure. Two type of degradation can be analyzed: one occurring during operation and the second during the test. The cell normal operation did not show significant degradation while during periodically measurements, in particular during polarization OCV a significant degradation occurred. It seems that OCV conditions are critical when operating with the contaminant, this assumption is confirmed when polarization tests were performed closing toluene line and no degradation was observed. Cell degradation can be, then, controlled if no OCV condition are used during the test and, in general, the contaminant does not cause continuous voltage decay in this specific conditions.

Difficulties encountered

As previously discussed, tests used were very intrusive due to voltage conditions during polarization curve and to EIS set-up during this specific test. In that sense, main indication for further activity is to perform polarization with no contaminant flow to avoid anode poisoning. Then OCV phases under toluene exposure must be avoided and, thus, EIS analysis must not be carried out at the OCV when the fuel cell runs on toluene-laden simulated syngas.

Further comments

The user is interested in continuing the study and a cooperation will be developed with the facility owner (University of Perugia).