Institute of Engineering Thermodynamics

Experimental Investigation of Anode/Cathode Differential Pressures for a SOFC/Gas Turbine Hybrid Power Plant

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Introduction

- Providing electrical energy with a reduced CO_2 footprint and in a sustainable way is a significant challenge for the future
- Therefore the DLR is installing a pilot hybrid power plant consisting of a small gas turbine and a pressurized SOFC
- Figure 1 illustrates the combination of the small gas turbine and the SOFC system

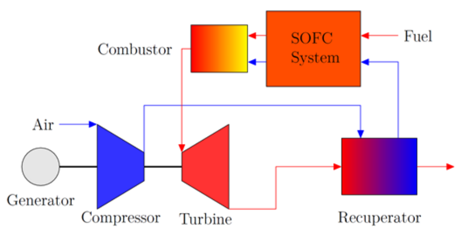

Figure 1: Hybrid Power Plant Scheme

Motivation

- The gas turbine provides air for the SOFC system at approx. 400 kPa
- The combustor burns the exhaust gas of the SOFC which is expanded in the turbine (with optional fuel supply and preheating of the SOFC air)
- Pressure variations caused by the gas turbine do not change the 400 kPa pressure level of the fuel gas
- Pressure differences between anode and cathode cause mechanical stress at the cells and sealings
- Experimental data about differential pressure on electrolyte supported cells (ESC) is needed
- The test procedures shown within this contribution are designed to identify potential failure mechanisms and maximum pressure differences

Stacks

- Two-cell stacks open cathode toward the surroundings
- Therefore the DLR and the stack manufacturer developed a specific design of a stack box to encapsulate the cathode volume from the surroundings to measure and control the cathode pressure

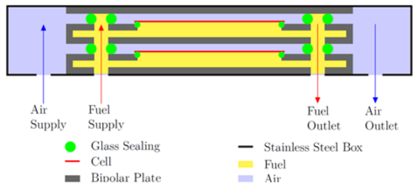

Figure 2: Specimen design schematic

- Sealings are made of glass ceramic material

Experiments

- The stacks are operated at 850 °C and are compressed with a force of 1200 N
- Separate pressure controller for anode and cathode volume
- Four heat exchangers to heat and cool the gases within the control loop

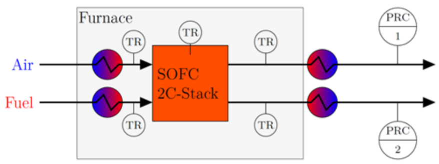

Figure 3: Tests rig schematic

- Several leakage test prior to the experiments are performed to identify potential handling or fabrication issues
- Cathode gas: air
- Anode gas: 95/5 vol.-% N_2/H_2
- Potential failure mechanisms are reviewed with a post mortem analyses (PMA) for each stack
- Figure 4 shows the determination of the point of stack failure

Results

- So far 14 tests with slowly increasing pressure difference (stationary test) have been carried out (compare Figure 5):
  - seven tests with anode excess pressure (A vs. C; blue)
  - four with cathode excess pressure (C vs. A; red)
- Three stacks failed the leakage test This is due to potential fabrication or handling issues
- Test results show large spread so additional tests are needed
- No evidence was found for cell failure
- Post mortem analysis indicate sealing failure as single failure mechanism

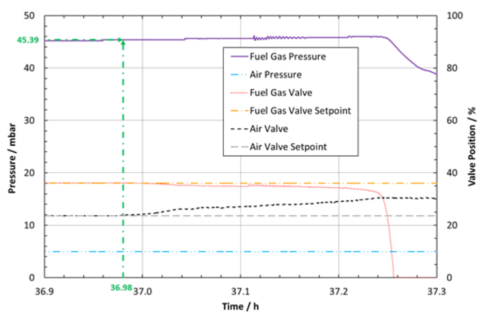

Figure 4: Determination of point of failure.

For further information of the analysis of the given results and upcoming tests please see contribution B1505 in EFCF 2014 from Mike Steilen (DLR).

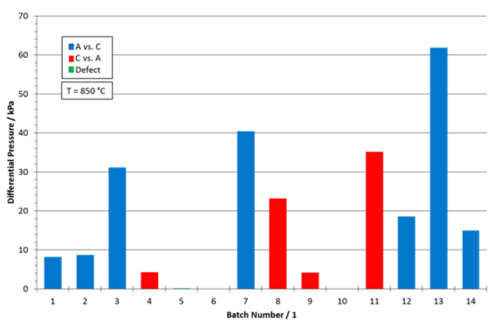

Figure 5: Differential Pressure Test Results

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