Introduction

With respect to the application of stainless steel for bipolar plates in the SPFC, the following topics are addressed:

- Resistance at the electrode backing/plate interface (A), caused by the protective oxide layer of stainless steel,
- Corrosion of steel in case of direct contact with the electrolyte (B), of interest for novel gasket-free designs,
- Corrosion, in cells where gaskets prevent direct contact of the plate material and the electrolyte (C).

Schematic presentation of single cell in housing, with indications of areas addressed here.

The work represents part of the ECN activities of a project carried out with Siemens and the Paul Scherrer Institute, with EC support within the JOULE III programme under contract JOU3-CT95-0027
Experimental technique

A novel technique was used to provide information on the Ohmic losses that result from the metal oxide layer covering stainless steel.

A thin gold wire is inserted between the electrolyte and electrode, to measure the potential loss across the backing / plate interface. The measured potential $V$ is the sum of Ohmic losses at the interface and the bulk resistances of electrode, backing and plate.

The bipolar plate material under investigation was present at one side only, graphite was used for the other plate. Thus, the suitability of alloys can be studied in relation to the environment they are exposed to.
Cells and operating conditions

MEA: 8 cm², N117, E-tek 0.4 mg/cm² Pt

\( T_{cell} = 65 \, ^\circ \text{C}, \, p = 1.5 \, \text{bar} \)

\( \lambda_{\text{Air}} = 2, \, \lambda_{\text{H}_2} = 1.5, \, \text{rel. hum.} = 100 \, \% \)

Cycled potential: 0.5 V & OCV (55/5 min)

Low compacting pressure: 4 bar

Validation of gold wire technique

To provide relevant information on the contact resistance, the measured voltage drop must be Ohmic, i.e. there should be no influence of redox reactions occurring in the electrode.

The voltage drop as measured with gold wires embedded in both electrodes is proportional to the current density, whereas cell polarisation is non-linear. So, the voltage drop is Ohmic, which validates the technique.
**Results, corrosion**

A total of 7 alloys was tested. With most alloys, corrosion was only visible in case of direct contact between alloy and electrolyte.

Accumulation of metal ions in the MEA was observed in cell configurations with and without direct contact between the alloy and the electrolyte. In case of direct contact, accumulation in the MEA was high: up to 1000 mg/kg/100hr. In most cases, accumulation was highest with the alloy present at the anode side. The graph shows results for the best alloys.

In a configuration with alloy anode plate and graphite cathode plate, it was found that metal ions were concentrated in the cathode catalyst layer.
Results, contact resistance

The contact resistance is strongly dependent on the compacting pressure the alloy and the plate pre-treatment. With a suitable pre-treatment and using alloy B, the total of contact resistances could be kept below 50 mΩ·cm².

Results, longevity tests

Alloy B was used for longevity tests. Cell 1 (J1) has the alloy plate at the cathode, cell 2 (J2) at the anode. The discontinuities of R occurred after a temporarily test shutdown in which the compacting pressure was reduced. Some degradation of cell performance is observed. Reference experiments using graphite plates never lasted longer than 3000 hrs, and showed similar behaviour.
In situ resistance reduction

Experiments using SS 316L plates at 30 bar compacting pressure revealed low contact resistances, being lowest at the anode. Switching gas flows resulted in low values at both sides. It is concluded that the oxide layer is reduced under conditions present at the anode.

Conclusions

- alloy B has low contact resistance, resulting in a loss of $\leq 25 \text{ mV @ 500 mA/cm}^2$
- the lifetime of cells with metal plates meets requirements for automotive applications
- resistance losses are highest at the cathode, corrosion is highest at the anode
- none of the steel types performed well when in direct contact with the electrolyte
- the gold wire technique is a valuable tool for measuring contact resistances