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Pressurized alkaline electrolyser with high efficiency and wide operating range – the project RESelyser

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Abstract

The project RESelyser has developed high pressure, highly efficient, low cost alkaline water electrolysers that can be integrated with renewable energy power sources (RES) using an advanced membrane concept, highly efficient electrodes and a new three-compartment cell design. A new separator membrane with internal electrolyte feeding and an adapted design of the cell to improve mass transfer, especially gas evacuation has been investigated and demonstrated. Intermittent and varying load operation with RES has been addressed by improved electrode stability and a cell concept for increasing the gas purity of hydrogen and oxygen especially at partial load and high pressure operation.

The results of the project will be presented: high performance electrodes with a plasma sprayed coating layer give an overpotential reduction of 330 mV compared to uncoated electrodes thus showing high performance and stability with low cost material. Detailed investigation of the electrode pore structure and microstructure at beginning of life and after operation shows possible degradation mechanisms. It was found that by feeding KOH solution from inside the internal compartment of a double layer diaphragm towards both the anolyte and catholyte compartments improves the gas purities of the cell significantly. The novel three-compartment cell concept using this double layer diaphragm was realized in single cells of 300 cm^2 area and in a 10 kW stack.

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Details of this presentation will be published elsewhere [1].

Introduction

For wide-spread use of electrolysers for energy storage by converting surplus renewable electrical energy to hydrogen the main obstacles are the costs of the device and the limited adaptation to fluctuating power supply. To adress these points the project RESelyser has developed concepts and materials for high pressure, highly efficient, low cost alkaline water electrolysers that can be integrated with renewable energy power sources (RES) using an advanced membrane concept, highly efficient electrodes and a new cell design.

1. Scientific Approach

A new separator membrane with internal electrolyte circulation and an adapted design of the cell to improve mass transfer, especially gas evacuation has been investigated and demonstrated. Intermittent and varying load operation with RES has been addressed by improved electrode stability at high efficiency and a cell concept for increasing the gas purity of hydrogen and oxygen especially at partial load and high pressure operation.

2. Experiments

Novel separators ("E-bypass separator") (Figure 1) with internal electrolyte bypass and properties for maximum benefit of the cell were developed (Figure 2) and produced in technical size of more than 2500 cm^2 cell area. The cell design was adapted to integrate this E-Bypass membrane.

Electrode coatings with low-cost material were developed with overpotential reduction versus uncoated Nickel electrodes of 210 mV for the cathode and 161 mV for the anode. The Vacuum Plasma Spray (VPS) electrode coating is demonstrated up to 2500 cm^2 electrode size. Figure 3 shows the combination of all new materials and concepts: VPS coated anode and cathode with e-bypass separator in an adapted single cell of 300 cm^2 cell area. A major increase of the cell efficiency is verified with a 300 cm^2 cell. The porosity of the coating layer was characterized by FIB-SEM (Figure 4) identifying pores at a wide range of scales.

The gas impurity at low current density is decreased to 25% of the value for a conventional cell.
A single cell (300 cm^2) and a 10 kW stack with E-bypass membranes integrated are in operation. The design of a high pressure stack (50 bar 300 cm^2) is ready and first tests were performed.
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Figure 1: "E bypass" double layer separator

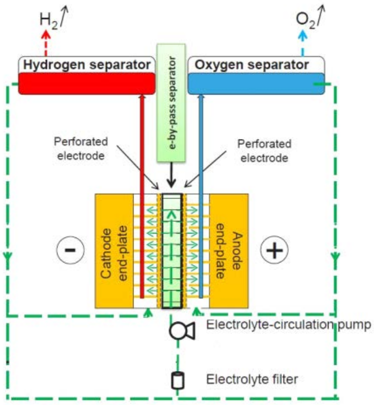

Figure 2: System concept using „E-bypass" double layer separator with internal electrolyte channel. Improved gas quality at high pressure.

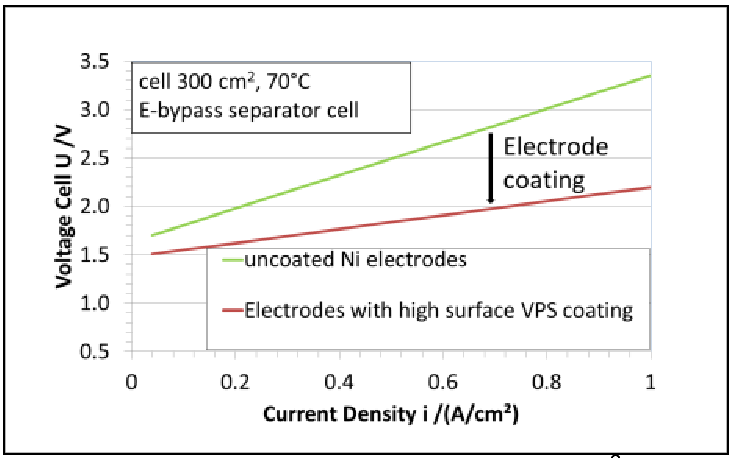

Figure 3: Current voltage curve of 300 cm^2 single cell with uncoated and low cost coated Ni electrodes

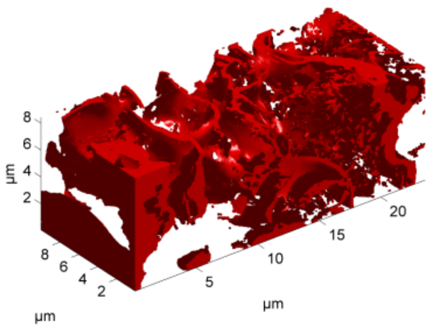

Figure 4: Pore structure of electrode coating analysed by FIB-SEM and 3D reconstruction

Figure 5: Stack (24 cell 10 kW) with „E-bypass" separator concept integrated

3. Conclusion

Key steps towards a next generation alkaline water electrolyser for higher pressure and highly fluctuating power were achieved.

References

[1] Final report of the project RESelyser, available via www.reselyser.eu or www.fch.europa.eu/ and further references therein