Improved electrodes and gas impurity investigations on alkaline electrolysers

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Alkaline water electrolysis for hydrogen production is a well-established technique available commercially in a wide power range. Hydrogen production by electrolysis is increasingly studied as a way to smoothen the fluctuating power output of renewable energy sources in oversupply situations. However, some technological issues regarding the coupling of alkaline water electrolysis and Renewable Energy Sources (RES) remain unadressed. The presented research aims at improving present electrolysers for the specifics of direct coupling to fluctuating power operation. Also system costs have to be decreased to reach a low cost but high-efficiency energy conversion. One of the aspects is to make a high current density, high efficiency low cost electrolyser that can tolerate periods of not being operated without degradation. Electrodes with low cost coatings for this purpose are presented here. Another aspect is the high gas impurity in conventional alkaline electrolysers at low current density and high pressure. Investigations on gas impurities in conventional design as well as with an advanced separator design in varying flow modes are presented here.

Efficient electrodes are prepared by vacuum plasma spray deposition of catalyst powders at DLR onto plain nickel electrodes. The electrodes with Raney-nickel-alloy coatings give an overpotential reduction of 330 mV compared to uncoated electrodes thus showing high performance with low cost materials. Long term on-off tests were performed in half cells. Considering only the electrode potentials of anode and cathode together an excellent stability was demonstrated: after 1100 on-off cycles 98% of the initial efficiency was retained.

A 300 cm^2 single cell electrolyser was investigated with different options of KOH supply and flow in a flexible test station. One electrolyser setup was a conventional cell with a single layer commercial separator, another one with an advanced separator. The advanced separator design, the E-bypass separator, is composed of two adjacent separator layers which are tied together and spaced-apart at the same time. Between the two separator layers the e-by-pass separator will comprise an integrated electrolyte by-pass-channel. This internal electrolyte channel is used for creating an electrolyte circulation by-pass stream, between and through the two adjacent separator layers. In this by-pass, the electrolyte will be forced to flow through the complete surface of the two separator layers. In this way the hydrogen gas that is dissolved in the catholyte compartment as a consequence of pressure is prevented from diffusing to the anolyte compartment. It was the purpose of these tests to investigate the gas impurities (hydrogen in oxygen, oxygen in hydrogen), especially at low current density and to find a flow and cell configuration with minimized impurities. A comparison of conventional separator single cell and e-bypass-separator cell measurements show that the hydrogen in oxygen impurity was reduced by at least a factor of 4 in the single cell due to the e-bypass-separator. The oxygen in hydrogen impurity is reduced to approximately 72%. I.e. there is a clear advantage using the e-bypass-separator, the cell can be operated at higher pressure and/or lower current density before reaching the limiting gas concentration. However what can also be seen from these measurements is that the gas impurity in an electrolyser depends on many more factors than what separator is used.

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