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Hydrogen and syngas production by solid oxide electrolysis with solar heat integration

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Abstract

Solid oxide electrolysis is especially attractive in terms of efficiency if coupled with a high temperature heat source. The external thermal energy can be used to evaporate the supplied process water and to heat up the steam and/or the carbon dioxide to the required electrolysis temperature. The external heat is ideally generated by renewable and environmental-friendly sources, such as solar radiation. The main challenges in this approach is the coupling between an intermittent heat source and the solid oxide electrolyser stack and its operation with environmental varying conditions while enabling high efficiency and low degradation.

Here we report the recent results of the project “Future Fuels 2” at the German Aerospace Center (DLR). The aim is to investigate the production of green hydrogen and syngas by means of solar heat integrated solid oxide electrolysis. In this project a test platform for syngas production was developed at DLR, consisting of a solar thermal steam generator and 12-cells stack, which was supplied by SOLIDpower S.p.A (Mezzolombardo, Italy). The solar heat was supplied by a high flux solar simulator based on elliptical reflectors with 10 xenon short-arc lamps. The test platform optimizations, e.g. reduction of the heat losses, minimization of steam instabilities and increase of the steam temperature, are outlined.

Results on the stack behavior in steam and co-electrolysis are presented and discussed. The stack was operated for 200 h in co-electrolysis mode under intermittent supply of steam, and CO_2, powered with solar heat and of electrical power, respectively. These varying operating conditions simulate fluctuations of the renewable energies, e.g. high solar radiation, clouds formation and day-night cycle. Both, in steam- and in co-electrolysis the SOEC stack showed a very good and homogeneous behavior at 750°C and 90 % gas conversion. In order to convert 90 % of the supplied process gases, which corresponds to 7.5 slpm of produced H_2 or $CO+H_2$ syngas, an electrolysis power of ca. -1.5 kW was necessary. High electrical efficiencies of 89% (steam electrolysis) and 93 % (co-electrolysis) were achieved. The stack behaviour in both electrolysis modes was almost identical. During the intermittent operation altogether 14 000 liters of syngas (H_2+CO) were produced successfully. Moreover, the stack degradation was very low.