Long-term AC:DC operation of a 70-cell SOE stack

Jensen, Søren Højgaard; Smitshuysen, Thomas Lyck; Mattera, Federico; Cui, Xiaoti; Zhong, Like; Montinaro, Dario; Ouweltjes, Jan Pieter

Publication date:
2023

Document Version
Early version, also known as pre-print

Long-term AC:DC operation of a 70-cell SOE stack

Søren Højgaard Jensen (1,2), Thomas Lyck Smitshuysen (1), Federico Mattera (1), Xiaoti Cui (2), Like Zhong (2), Dario Montinaro (3), Jan Pieter Ouweltjes (3)

(1) DynElectro ApS. Syvvejen 10, 4130 Viby Sjælland, DK
(2) AAU, Department of Energy. Pontoppidanstræde 111, 9220 Aalborg, DK
(3) SolydEra SpA. Viale Trento 115/117, 38017 Mezzolombardo, IT

Tel.: +45 2132 7932
soren@dynelectro.dk

Abstract

The ongoing green energy transition increases the need for dynamic and efficient Power-to-X (PtX) systems to convert wind and solar power to green fuels and chemicals. Amongst the different electrochemical conversion technologies, solid oxide electrolysis (SOE) technology offers the highest energy conversion efficiency. However, operation below thermo-neutral potential, which is a likely event due to the fluctuations in power, creates thermal variations and thermomechanical stress. This, combined with degradation mechanisms such as Ni migration and electrode poisoning, limits the SOE lifetime and impedes commercialization of the technology.

Here, we present a novel operating method that alleviates temperature variations under fluctuating power and reduces SOE degradation. The operation method relies on operating the SOE stack with a mix of alternating current (AC) and direct current (DC) and is therefore referred to as AC:DC operation. AC:DC operation establishes a flat thermal profile across the SOE, by switching several times per second between electrolysis mode and fuel cell mode, the thermal mass of the SOE preventing temperature fluctuations during the short switching period.

Further, for steam electrolysis Si-based impurities can be desorbed from the fuel electrode via formation of $Si(OH)_4$ during the pulses in fuel cell mode. Since Si-impurities are considered a precursor for Ni-migration, AC:DC operation helps to suppress Ni-migration.

In this presentation we present experimental results and impedance measurements from a 5000+ hour 70-cell SOE stack test, with a remarkably low degradation rate.