Description for the general public

Solid oxide electrochemical cells (SOC) are complex electrochemical devices made of three basic functional layers – two electrodes separated by an electrolyte. Generally, the electrochemical cell which can be operated in a fuel cell mode, generates electricity while fuel and oxidant are consumed. It is known that systems with electrochemical cells which can be reversed or operated in regenerative mode or operated in electrolysis mode. Such cells are commonly called SOEC – solid oxide electrolysis cells. In such cells, hydrogen and oxygen are generated from water vapour using electricity.

Operation of solid oxide electrolyser requires, in the conventional approach, continuous feeding of steam to the cathodic compartments and air to the anodic side for SOE. The flow of O_2/N_2 mixture can be however replaced also by the steam. But steam in the anodic compartment will not react electrochemically(like on the cathode side) but will be used as a sweep gas which task is to take away produced oxygen. In this manner simple cooling down of the outlet stream would separate condensed water and pure oxygen that has been released in the cell. In this case the by-product of the electrolysis process oxygen that usually is discarded, could constitute additional value for the high temperature electrolysis.

The feasibility of this concept requires experimental verification and identification of steam influence on the behaviour of anode material which usually is not subjected to the high steam content. For that reason it is necessary to perform a complete comprehensive experimental analysis using advanced electrochemical methods to determine degradation rate of the cell and find out more about stability of the oxygen electrode material in this conditions.

Knowledge resulting from the proposed project can aid in future to mitigate problems related to the higher contribution of the oxygen electrode to the ohmic losses of the cell and find new strategies for material research. Additionally, it will make it possible to define new routes for high temperature electrolysis development that emerges when pure oxygen production together with hydrogen will be possible in one electrochemical process.

Research tasks planned in the project include experimental characterization of oxygen electrode material in extremely high steam content under various current density conditions. One of the key elements of the project is perform long-term analysis of the high temperature electrolysis cells which will allow to determine the oxygen electrode material contribution to the degradation rate and will find basic values for future economic analysis. Finally project aim is to qualify the possibility to obtain simultaneously pure oxygen and hydrogen in the same electrolysis process and try to measure quality of the produced gases.

The *post mortem* microstructural studies are a complementary activities which will allow to search for the degradation mechanism and other stability problems that are related to the anode material if such/any degradation will occur. They will also complete the picture that will be obtained from impedance spectroscopy measurements during long-term testing and help to draw conclusion about material stability from each experimental test.

In broad global aspect, results of the project can accelerate the development of solid oxide electrolyzers. Such systems can be applied in power sector, which will comprise intermitted energy sources (renewables such as wind, PVs, etc.) which require storage capabilities. Use of SOEC allows to store the excess electricity in a form of hydrogen generated via the electrolysis.