Research and Innovation Centre PRO-AKADEMIA

Highly Efficient Molten Carbonate Fuel Cells

Reducing CO_2 emission, while not limiting the power generation

Sector: Energy
Overall budget: 1.5 M EUR
Countries involved: PL
Funding: National Center for Research & Development
Duration: 2015 - 2018

- MCFC: a CO_2 separator without an energy penalty
- How to use less Nickel while maintaining the performance?
- Corrosive electrolyte is a challenge for the material engineers

Introduction

The increasing demand for energy together with increasing energy price of energy leads to the need of introducing new energy production systems with high efficiency. Fuel cells, thanks to their numerous advantages, can become a future environment-friendly source of electrical energy and heat, and are especially interesting to be used in distributed energy generation systems. Solid Oxide Fuel Cells and Molten Carbonate Fuel Cells represent the high-temperature fuel cell systems – due to their high electrical efficiency they are considered to be one of the future energy sources. Currently constructed SOFC and MCFC systems have an electrical **power output ranging from kW range to 10 – 20 MW**, and thanks to intense research efforts further power output increase can be expected. Therefore, these devices are likely to become an alternative in the future power engineering.

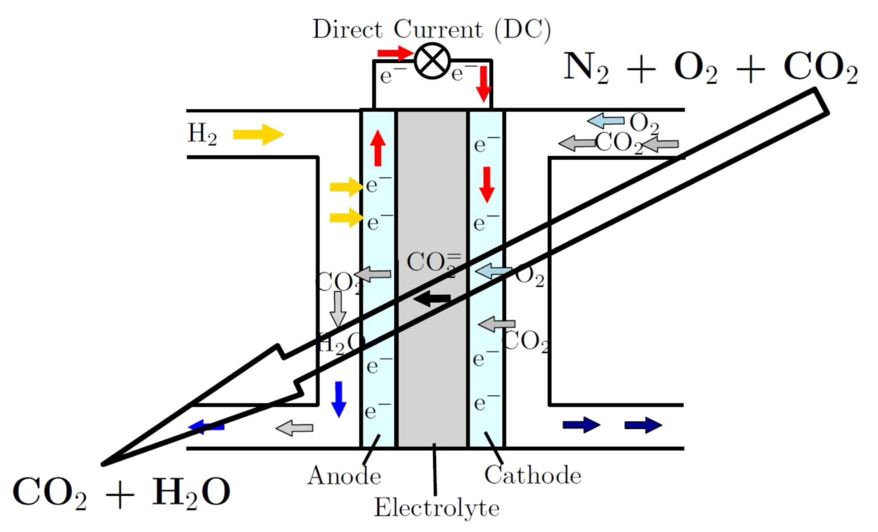

Figure 1: MCFC working principle

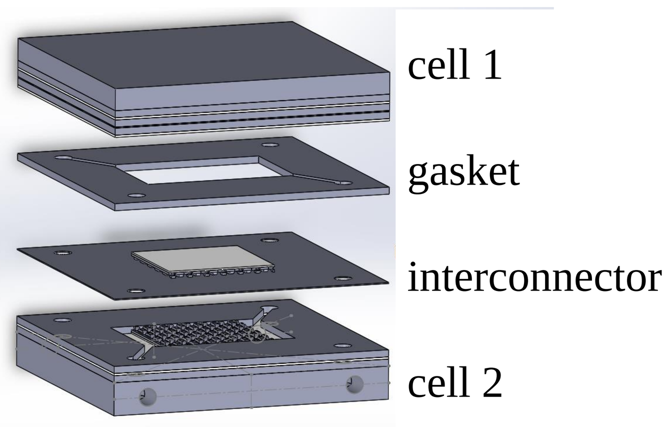

Figure 2: Schematic view of an MCFC stack

An important feature of the MCFC is the **possibility of CO_2 separation**, as shown in Figure 1. This puts the MCFC in the range of alternative CCS solutions, as an alternative for solvent-based CO_2 separation methods **without an energy penalty**. An example of a configuration of a MCFC with a coal-fired boiler is shown in Figure 3.

About the project

The purpose of the project presented here is to develop **new materials and structural (engineering) solutions** for molten carbonate fuel cells --- one of the high-temperature fuel cell types.
The performance of the fuel cell is influenced both by considerations of material (material layers: the anode, cathode, matrix, and electrolyte) as well as heat-flow (construction of collectors supplying fuel and oxidant), proper heat management cell, etc. See Figure 2.

The project envisages cooperation of the four R&D centers and one private company:

→ the Faculty of Power and Aeronautical Engineering of Warsaw University of Technology: thermal and flow issues, single cell tests, the use of artificial intelligence;
→ Department of Materials Science and Engineering of Warsaw University of Technology: material issues, test cell components preparation;
→ the Faculty of Chemical Engineering of Łódź University of Technology – cell degradation and corrosion measurements;
→ Research & Innovation Centre Pro-Akademia – techno-economical analyses;
→ the company SKA Polska sp. z o.o. – stack manufacturing.

Specific objectives of the Highly Efficient Molten Carbonate Fuel Cells project include:

→ The development of guidelines for the **new material and structure solutions for the MCFC**
→ The analysis of the structure and the optimization of materials for the MCFC, **the development of production technology**
→ The investigation of the **material degradation** processes in MCFC
→ The study of electrochemical properties and the optimization of electrode materials taking into account their vulnerability to **high-temperature corrosion**
→ The development of new solutions related to the structure of the MCFC
→ **Techno-economical analyses**

Implementation methods

First a reference point for the performance of the fuel cell is chosen. Then the different construction materials of the fuel cell stack are studied and modified. Their performance is compared in terms of the **Levelized Costs of Energy (LCoE)**. The fuel cell performance data collected during the experiments is immediately circulated to the partner responsible for the economical analysis in order to gain feedback if the implemented change led to the desired lower LCoE, or vice versa. Also the data from the material degradation experiments are included in the economical analysis in order to take into account the performance reduction over the expected lifetime of the stack.

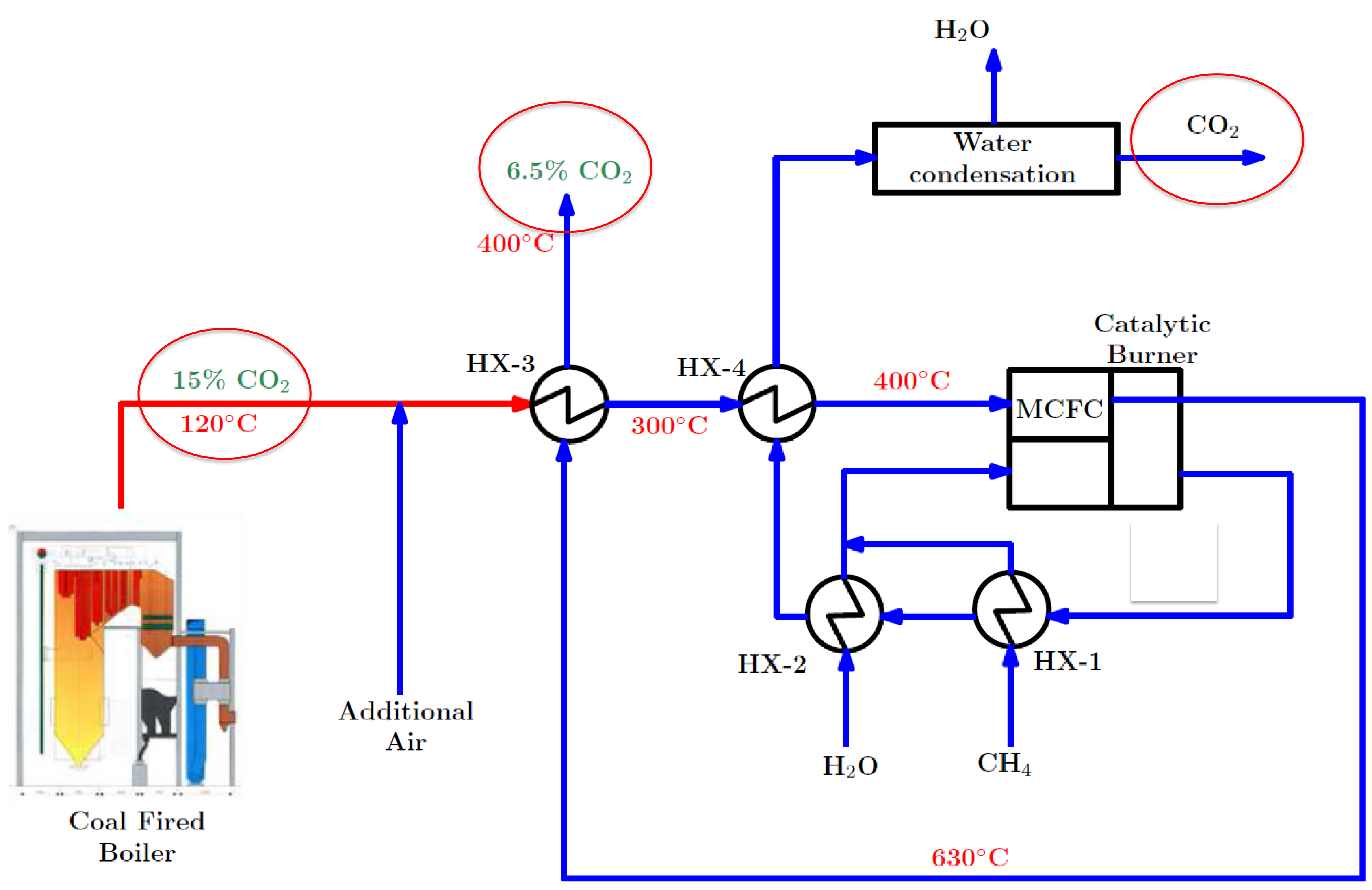

Figure 3: Possible configuration of an MCFC with a coal-fired boiler for CO_2 separation

Expected results

The main investment cost in the case of an MCFC is related to the necessary amounts of:

→ Nickel (anode and cathode)
→ Lithium alumina (electrolyte matrix)

The costs of the anode, cathode and the electrolyte matrix currently sum up to more than **70% of the costs** of the fuel cell. Therefore the expected project results include:

→ guidelines for MCFC structure having considerably extended lifetime, reliability and corrosion resistance compared to the current state-of-the-art solutions;
→ guidelines for the selection of construction materials allowing to reduce the investment costs of the MCFC system and minimizing the Levelized Cost of Energy (LCoE), as a comparison method between different system configurations;
→ development of new solutions related to the structure of the MCFC for the enhanced system performance and reliability.

Acknowledgements

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The National Centre for Research and Development

PBS Program Badań Stosowanych

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