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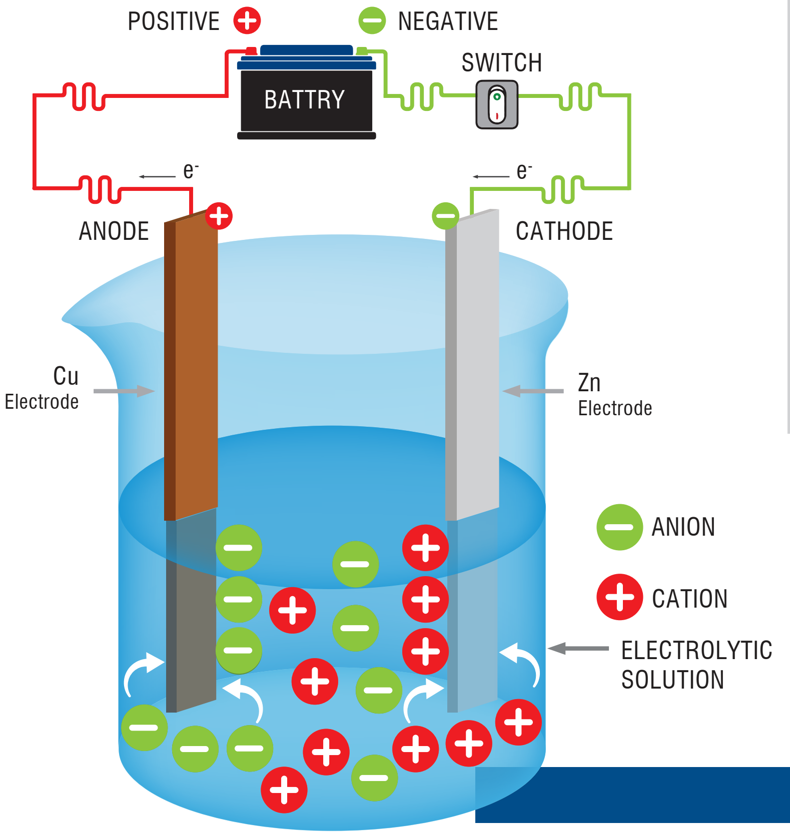
HYDROGEN

Simulation of processes and technologies for production and use in industry



Polymer Electrolyte Membrane Electrolyzers

The recent increasing demand for alternative fuels is leading to the fast development of technologies devoted to hydrogen production at industrial level. The interest in hydrogen as an alternative fuel comes from its ability to power fuel cells in zero-emission vehicles, its potential for domestic production, and the fuel cell's fast filling time and high efficiency.

Moreover, hydrogen is widely recognized as a key component for storing large quantities of renewable electricity over longer periods: it works as renewable energy "bank" for power systems upon request.

For this reasons hydrogen production and usage are now the goals of several companies which work in the energy sector.

Polymer electrolyte membrane (PEM) electrolyzers are industrial plants that produce hydrogen (and oxygen) through the **electrolysis of water.**

This process is based on the chemical reaction of water and electrical energy, which results in the segregation of water into its components hydrogen (H_2) and oxygen (O_2).

The PEM electrolysis takes place in a unit called "cell" and employs a polymer membrane which guarantees the proton exchange, gas formation and liquid insulation. Each unit is called "cell" and the current transmission takes place in a cell which is equipped with a polymer membrane.

The electrolyte fluid flows in a dedicated circuit, which connects thousands of cells; during the passage through each cell, the electrolyte collects hydrogen and oxygen gases. To maximize the efficiency, the liquid and the gas flows must be correctly designed and balanced.

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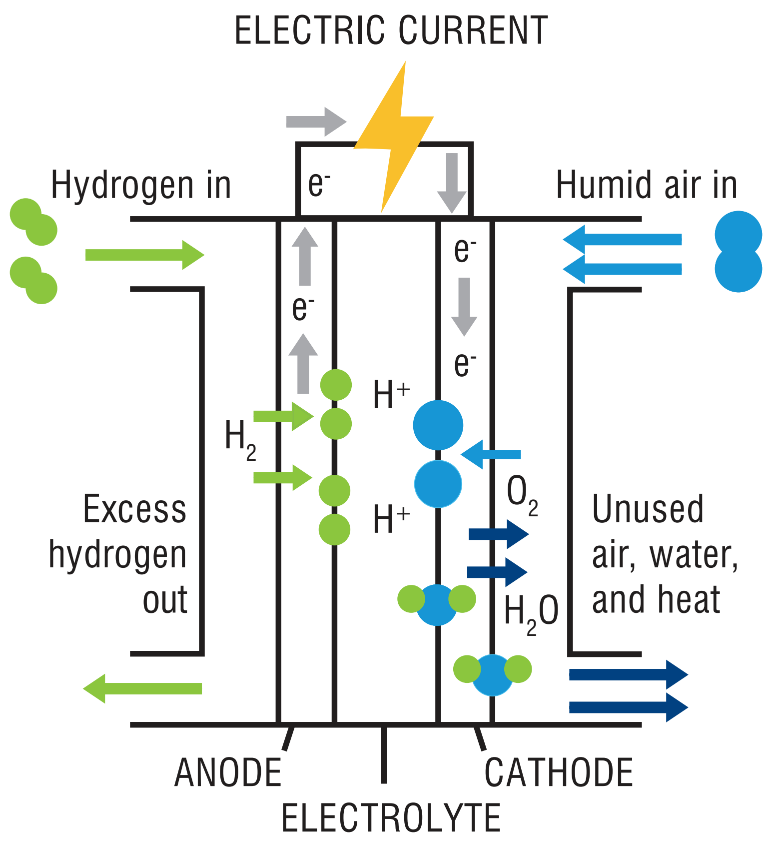


Proton Exchange Membrane Fuel Cells

The proton exchange membrane (PEM) fuel cell consists of a cathode, an anode and an electrolyte membrane. Hydrogen flows at the anode side and the oxygen (transported through an air flow) is present at the cathode. Protons are transported from the anode to the cathode through the electrolyte membrane and the electrons are carried over an external circuit load.

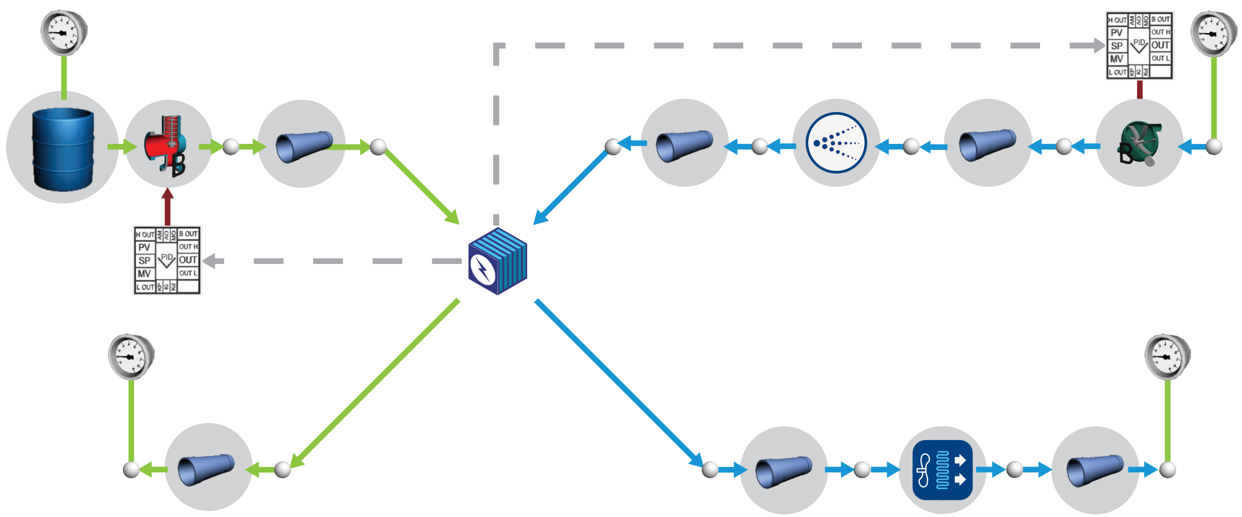
At the cathode, oxygen reacts with protons and electrons, producing heat and generating water as a by-product.

One of the key elements for an optimum performance is to maintain proper humidity at the cathode-side air flow of the fuel cell.

When water is removed at a lower rate than the supplied water, the surplus water hinders the transport of reactant gases by blocking the pores in the gas diffusion layers and catalyst.

Membrane dehydration takes place when the removal rate of water is higher than the generated water, consequently resulting in a performance degradation.

Polymer electrolyte membrane (PEM) fuel cells are mainly developed for portable fuel cell applications, transport applications as well as stationary fuel cell applications.



A Flownex network of the PEM Fuel Cell

FLOWNEX®
SIMULATION ENVIRONMENT

Flownex is a product of M-Tech Industrial (Pty) Ltd

System Modelling

In this industrial sector, simulation models are focused on the CFD systems where chemical processes take places, considering each flow in the circuits (electrolyte, humid air, hydrogen). Using such approach, the model is a digital version of the PEM electrolyzer or the PEM fuel cell; virtualization supports the design and the performance calculation in different configuration scenarios.

The simulation tool Flownex SE is adopted to create a network, where each component represents a part of the cell and the auxiliary equipment: pumps, valves, heat exchangers, humidifier, compressors.

Flownex SE models the interaction of piping and process equipment together with the instrumentation and control devices.

Simulation of Polymer Electrolyte Membrane Electrolyzers

- Electrolyte flow balance and optimization
- Gas flow regime
- Analysis of system behaviour at critical modes
- Sensor failure simulation
- Cooling loops

Simulation of Proton Exchange Membrane Fuel Cell

- System component design
- Humidifier implementation and design
- De-humidifier design
- Transient behaviour with load changes
- Transient control for required air and hydrogen ratio required
- Required compressor power
- Cooling loops

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