CHALMERS
UNIVERSITY OF TECHNOLOGY

TRA 105 - Fuel Cell Systems

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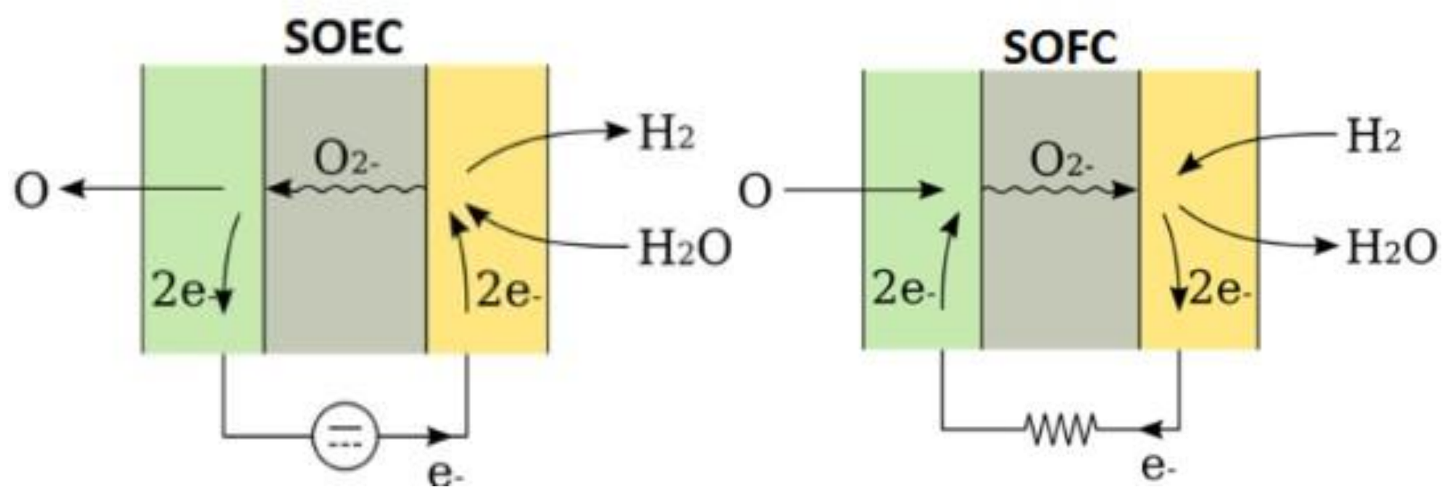
Constructing and operating a single cell solid oxide electrolyzer cell (SOEC)

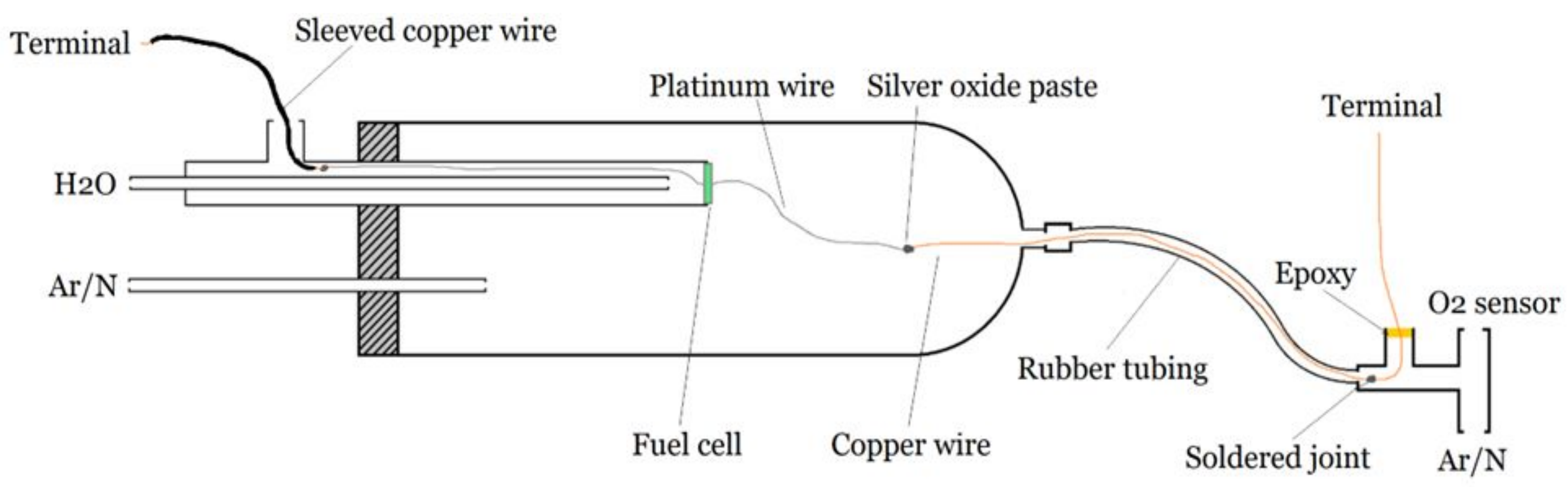
Background

The Cell used in this project is a Elcogen solid oxide fuel cell (SOFC). A SOFC operates in high temperatures, the one used in this project operates around 600-750℃ and therefore needs to be put in a furnace to work. When the cell is running in electrolyzer mode (SOEC), the process is reversed. Instead of using hydrogen to create electricity it creates hydrogen by supplying it with electricity. Although the SOFC can reach a total efficiency of 90% the SOEC can reach a even higher efficiency of 99% if the high quality waste heat is utilized, but the heat is not used in this project.



Setup/build

The construction of the setup is done by suspending the cell, being a delicate membrane, between two high-temperature gaskets secured at the edge of a metal pipe, with a nut twisted to keep it in place. The pipe is inserted into a glass tube, with an other inlet to flush out air by filling the glass tube with argon. At the other end of the glass tube there is an exit for the gases where a O_2 sensor is connected. The terminals was drawn out to through the pipe and tube. The setup is shown in the figure below. The setup is inserted into the furnace and set to 620℃.



The system is sealed to measure the produced O_2. On the left, the H_2O vapor is fed. There are two pipes, the smaller tube feeding H_2O vapor, with the larger tube as return. This is done so that there is a exit for the gases ($H_2$and H_2O vapor) but still making sure the cell is fed H_2O vapor by having the smaller pipe close to it. On the right is the system that releases O_2, measured by a sensor at the exit.

Operation

- The furnace heats up the system to 620℃.
- Argon (neutral gas) is used to flush out atmospheric air out of the glass tube, using the O_2 sensor to make sure no O_2 is left.
- A humidifier releases water_vapor into the H_2O inlet, and when the appropriate voltage is applied, the water vapor splits, releasing O_2 gas into the glass chamber.
- Valves are used to send the newly formed gas through the O_2 sensor, which returns the O_2 values in ppm in the enclosed volume.

Special thanks to Matthiue Tomas for helping us with the project

Results

- The initial value was 0 ppm of O_2 in the system, however, due to a leak, the value increased to 4.155ppm of O_2.
- The setup when started, produced 5.541ppm of O_2 , at 1V and 0.550A of current applied for 15 minutes.
- The limiting area for current density for this cell was calculated to be 0.644 A/cm^2.
- Further, increasing the applied current to 0.602A for 25 minutes yielded an additional 1.125ppm of O_2.
- After the setup was turned off, the O_2 value decreased but not to it's initial value of 4.155ppm, due to limited time.
- After removing the tubes from the furnace, the fuel cell and tubes were observed to be intact.
- As a result, the thermal expansion of the sealed nuts has been identified as the source of the gas leak.
- The setup worked because there was a voltage across it, however, there is no reliable evidence of how much O_2 was produced.

Fig: Outer tube and inner tube with the platinum wire attached to it.

Discussions

- The setup used in this study could be tested over a day or two so that the O_2 sensor has time to stabilize after the experiment, yielding better results.
- To avoid the thermal expansion of the metal nuts used in this experiment, four high temperature, non-conductive bolts could be used in place of a nut to sandwich the fuel cell in a slit.
- Such thermal expansion could lead to leakage of O_2 gas thereby giving a false reading.

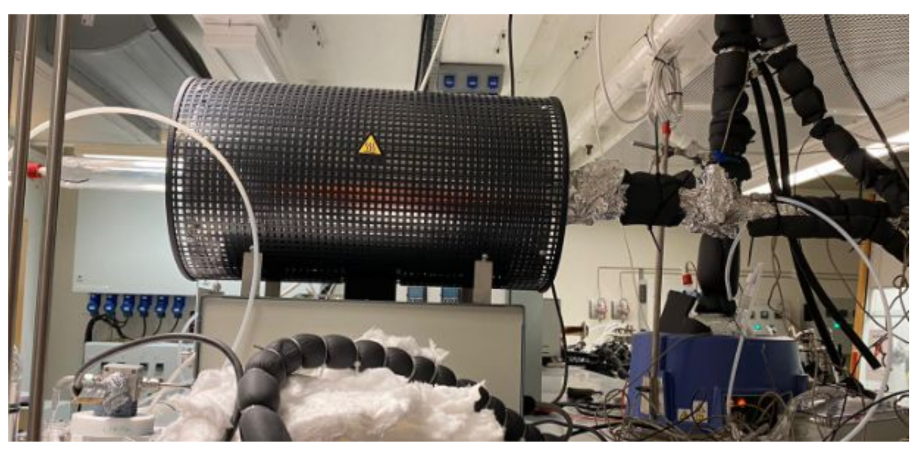


Fig: Setup inserted into the furnace.

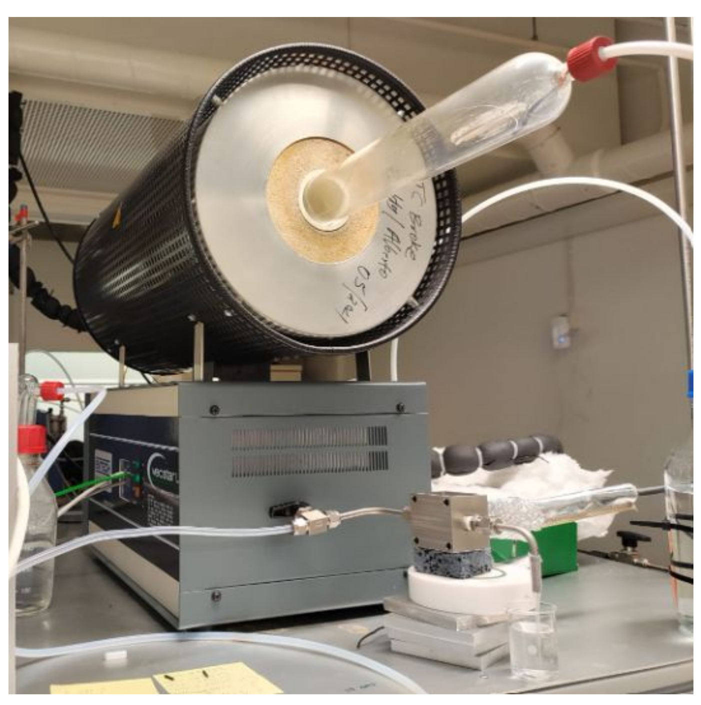


Fig: Anode side of the setup with the O_2 sensor.