

Quiz 3: Co-electrolyzer

1. Condition: SN = 3, O₂ concentration = 0.3 (COSOEAIR), T_{SOEC_in} = 700°C (SET-TSOE)

Currently the stack is operating at thermo-neutral voltage. Deactivate the corresponding design specification and change the CVELL initial value to 1.4 Volts (in OXY calculator block).

What is the outlet Temperature of the SOEC stack? in which mode does it operate?

- ☒ (A) T_{out_SOEC} = 754°C, exothermic mode
- ☐ (B) T_{out_SOEC} = 689°C, exothermic mode
- ☐ (C) T_{out_SOEC} = 689°C, endothermic mode
- ☐ (D) T_{out_SOEC} = 754°C, endothermic mode
- ☐ (E) T_{out_SOEC} = 700°C, thermoneutral mode
- ☐ (F) T_{out_SOEC} = 721°C, exothermic mode
- ☐ (G) T_{out_SOEC} = 692°C, endothermic mode
- ☐ (H) T_{out_SOEC} = 721°C, endothermic mode
- ☐ (I) T_{out_SOEC} = 692°C, exothermic mode

Initially, the thermoneutral voltage is ≈ 1.34 Volt. Increasing the voltage, we will increase the current and go in the exothermic region. Heat will be generated, and the outlet temperature of the SOEC will increase from 700°C to 745°C.

Also $T_{out} > T_{in}$ is the definition of exothermic operation.

2. Condition: TN-design spec activated, O₂ concentration = 0.3 (COSOEAIR), T_{SOEC_in} = 700°C (SET-TSOE)

Changing the design specification that control the Syngas quality, and target a SN ratio of 1. What is the temperature at which the fuel is at full vapour state ?

- ☐ (A) 102°C
- ☐ (B) 110°C
- ☐ (C) 100°C
- ☐ (D) 89 °C
- ☒ (E) 86°C

A SN ratio of 1, means the infeed stream will contain more CO₂. A higher CO₂ fraction implies a lower H₂O partial pressure, which makes its full evaporation happen “easier” i.e. at lower temperature.

3. Condition: TN-design spec activated, SN = 3. T_SOEC_in = 700°C (SET-TSOE)
Change the target O₂ concentration at the outlet of the SOEC to 0.99. What is the reason of the warning?

The flow of air is varied between 0.3 and 1 in the COSOEAIR, but should be almost 0 for a O₂ concentration of 99%. Design specification stuck at the lowest bound.

4. Condition: TN-design spec activated, O₂ concentration = 0.3 (COSOEAIR), SN = 3.

The thermo-neutral voltage is usually dependent on the operating temperature of the SOEC.
Change the temperature of the SOEC to 800°C, what is the new operating cell voltage to ensure thermo-neutral operation?

- (A) 1.326 Volt
- (B) 1.331 Volt
- (C) 1.347 Volt
- (D) 1.352 Volt
- (E) 1.359 Volt

At higher operating temperature, the thermoneutral voltage tends to increase.

5. Condition: TN-design spec activated, SN = 3. T_SOEC_in = 700°C (SET-TSOE), 0.3 (COSOEAIR), SN = 3.

Given:

LHV of H₂ = 33.33 kWh/kg

LHV of CO = 3.03 kWh/kg

what is the conversion efficiency of the SOEC stack (i.e. energy Syngas out / electrical power in)

- (A) ≈ 1
- (B) ≈ 0.98
- (C) ≈ 0.86
- (D) ≈ 0.82

At thermo-neutral operation, the efficiency is almost 1. This is the region where the entropic heat required for the reaction is provided by the ohmic losses. It is not exactly 1 though, due to the slight convergence tolerances for the design specifications.