Change log (hidden)

Annex 3 Reverse Water Gas Shift

This file calculates the costs of reverse water gas shift reaction (CO2 + H2 <==> CO + H2O).
Data were taken from: Rezaei and Dzuryk, 2019, Table 8 and figure 6.

Get libraries

Include << .\Libraries\Mw.mcdx

Include << .\Libraries\CEPCI.mcdx

Include << .\Libraries\Units.mcdx

Include << .\Generic data.mcdx

Include << .\Libraries\Molecular formulas.mcdx

The stoichiometry of the Reversed Water Gas Shift Reaction (RWGS) is given below.

$$CO2 + H2 = CO + H2O$$

Data taken from the paper:

$$\phi := 22500 \ \frac{kmol}{hr}$$

$$\tau_{operating} := 8240 \ \frac{hr}{yr}$$

$$refYear := 2017$$

$$f_{H2} := 0.6502 \qquad f_{CO} := 0.3271$$

$$\Phi_{CO} := \phi \cdot \tau_{operating} \cdot f_{CO} \cdot Mw(CO) = 1.699 \ \frac{10^6 \ ton}{yr}$$

Process energy (OPEX) (From table 8)

$$P_{fired\_heater} := 87.84 \ MW$$

$P_{compressors} := (51.45 + 27.34 + 27.02)\ MW = 105.81\ MW$

$P_{pump} := 1.22\ MW$

$P_{heater} := 1.48\ MW$

$P_{reb} := 350\ MW$

It is assumed that the reboiler heat is produced by a heat pump instead of NG.

$COP := 4\ \frac{J}{J}$ Heat pump efficiency $\frac{P_{reb}}{COP} = 87.5\ MW$

$P_{el} := P_{fired\_heater} + P_{compressors} + P_{pump} + P_{heater} + \frac{P_{reb}}{COP} = 283.85\ MW$

$p_{el\_RWGS} := \frac{P_{el}}{\Phi_{CO}} = 5.273\ \frac{10^9\ J}{ton}$ $\frac{P_{el}}{\Phi_{CO}} = 1.465\ \frac{MW \cdot hr}{ton}$

Investment costs

$C_{BM\_tot} := 113.45 \cdot 10^6\ USD$

$C_{NG\_heater} := 24.1 \cdot 10^6\ USD$

$C_{E\_heater} := \frac{C_{NG\_heater}}{2}$ An electric heater will be cheaper than a NG fired heater.

$C_{reb\_heatpump\_compr} := 17.568\ 10^6 \cdot USD$ Assuming extrapolation with scale factor of 0.6 (see Compressor scale factor.mcdx)

Correction for electric heater instead of gas fired heater and year of construction.

$CAPEX := (C_{BM\_tot} - C_{NG\_heater} + C_{E\_heater} + C_{reb\_heatpump\_compr}) \cdot \frac{CEPCI(2024)}{CEPCI(refYear)} \cdot CoC$

$CAPEX = 30.106\ \frac{10^6\ €}{yr}$

The investment costs for the reboiler are not subtracted as the heat exchange surface is still needed regardless of heat source (steam vs. heat pump)

CAPEX per ton of carbon monoxide produced:

$$capex_{RWGS} := \frac{CAPEX}{\Phi_{CO}} = 17.724\ \frac{€}{ton} \qquad \frac{CAPEX}{CoC \cdot \Phi_{CO}} = 88.619\ \frac{€}{\frac{ton}{yr}}$$

Literature

Rezaei and Dzuryk, 2019 [14]