Fuel Cell Stack Hydrogen, Air, Water and Heat

Hydrogen consumed and supplied, air flow, exit air, water produced and heat to remove for a hydrogen fuel cell stack of given power and cell voltage.

Method: Faraday's law applied to a hydrogen fuel cell stack

Input parameters

Unit system: SI

Parameter	Value	Unit
Stack electrical power	10.000	kW
Average cell voltage	0.65000	V
Number of cells	60.000	
Air stoichiometry	2.0000	
Hydrogen stoichiometry (supplied over used)	1.1000	

Calculated results

Parameter	Value	Unit
Stack current	256.41	A
Hydrogen used	0.57861	kg/h
Hydrogen supplied	0.63647	kg/h
Air supplied	39.683	kg/h
Exit air (dry, oxygen depleted)	35.091	kg/h
Water produced	5.1705	kg/h
Heat produced (water leaves as vapour)	9.2786	kW
Heat produced (water leaves as liquid)	12.785	kW

Notes for this case

• Faraday: each H_2 molecule gives 2 electrons, so ṅ_H_2 = P_e/(2V_cF) for the whole stack. Air from the oxygen used times the stoichiometry over the oxygen fraction of dry air. Heat = P_e(1.253/V_c − 1) when water leaves as vapour (1.481 V if liquid).

Formula and method

$$\dot{n}_{H_2} = \frac{P_e}{2 V_c F}, \quad \dot{m}_{air} = \lambda \frac{\dot{n}_{H_2}}{2\, y_{O_2}} M_{air}, \quad \dot{Q} = P_e \left(\frac{1.253}{V_c} - 1 \right)$$

Variables

P_e	Stack electrical power	W
V_c	Average cell voltage	V
n	Number of cells	-
λ_{air}	Air stoichiometry	-
λ_{H_2}	Hydrogen stoichiometry (supplied over used)	-
I	Stack current	A
$\dot{m}_{H_2}$	Hydrogen used	kg/s
$\dot{m}_{H_2,in}$	Hydrogen supplied	kg/s
$\dot{m}_{air}$	Air supplied	kg/s
$\dot{m}_{exit}$	Exit air (dry, oxygen depleted)	kg/s

$\dot{m}_{H_2O}$	Water produced	kg/s
$\dot{Q}_{LHV}$	Heat produced (water leaves as vapour)	W
$\dot{Q}_{HHV}$	Heat produced (water leaves as liquid)	W

Method and standards

Faraday's law and energy balance.

Assumptions and limits

- Steady state; all current from hydrogen oxidation.

References

Faraday's law applied to a hydrogen fuel cell stack

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/environmental/hydrogen-fuel-cells/fuel-cell-stack-flows

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.