Steam Methane Reforming: Hydrogen Yield, CO2 and Heat Duty

Hydrogen, carbon dioxide and steam balance and the reaction heat duty of steam methane reforming with water-gas shift, from methane feed and conversions.

Method: Steam reforming and water-gas shift stoichiometry with NIST-JANAF heats of formation

Input parameters

Unit system: SI

Parameter	Value	Unit
Methane feed	1,000.0	kg/h
Methane conversion in the reformer	92.000	%
Fraction of CO converted in the shift	95.000	%
Steam-to-carbon molar ratio	3.0000	

Calculated results

Parameter	Value	Unit
Hydrogen produced	456.66	kg/h
Carbon dioxide formed	2,397.5	kg/h
Carbon monoxide remaining	80.313	kg/h
Steam consumed by the reactions	2,014.5	kg/h
Excess steam leaving	1,354.2	kg/h
Hydrogen per kg of methane	0.45666	kg/kg
Process CO_2 per kg of hydrogen	5.2502	kg/kg
Net reaction heat duty at 25 °C (endothermic)	2,661.2	kW
Hydrogen mole fraction in the dry product gas	78.420	%

Notes for this case

• $CH_4 + H_2O \rightarrow CO + 3H_2$ (ΔH = +206 kJ/mol) then $CO + H_2O \rightarrow CO_2 + H_2$ (−41 kJ/mol); heats of reaction from NIST-JANAF formation enthalpies at 25 °C with steam as vapour. Fuel burned to heat the reformer adds roughly as much CO_2 again (about 9–10 kg CO_2 per kg H_2 in total for a plant).

Formula and method

$$CH_4 + H_2O \rightarrow CO + 3H_2, \quad CO + H_2O \rightarrow CO_2 + H_2, \quad \dot{n}_{H_2} = \dot{n}_{CH_4} X (3 + Y)$$

Variables

$\dot{m}_{CH_4}$	Methane feed	kg/s
X	Methane conversion in the reformer	-
Y	Fraction of CO converted in the shift	-
S/C	Steam-to-carbon molar ratio	-
$\dot{m}_{H_2}$	Hydrogen produced	kg/s
$\dot{m}_{CO_2}$	Carbon dioxide formed	kg/s
$\dot{m}_{CO}$	Carbon monoxide remaining	kg/s
$\dot{m}_{H_2O}$	Steam consumed by the reactions	kg/s
$\dot{m}_{H_2O,ex}$	Excess steam leaving	kg/s

m_{H_2}/m_{CH_4}	Hydrogen per kg of methane	kg/kg
m_{CO_2}/m_{H_2}	Process CO_2 per kg of hydrogen	kg/kg
$\dot{Q}$	Net reaction heat duty at 25 °C (endothermic)	W
y_{H_2}	Hydrogen mole fraction in the dry product gas	-

Method and standards

Reforming stoichiometry and heat of reaction.

Assumptions and limits

- Conversions given (not computed from equilibrium); heats at 25 °C.

References

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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

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