Hydrogen Compression Work and Power

Specific work and power to compress hydrogen in intercooled stages, against isothermal work, with stage outlet temperature and share of hydrogen energy.

Method: Multistage intercooled compression of an ideal gas

Input parameters

Unit system: SI

Parameter	Value	Unit
Suction pressure	3.0000	MPa
Discharge pressure	45.000	MPa
Suction (and intercooled) temperature	30.000	°C
Number of stages	3.0000	
Isentropic efficiency per stage	75.000	%
Heat capacity ratio (hydrogen 1.41)	1.4100	
Hydrogen flow	100.00	kg/h

Calculated results

Parameter	Value	Unit
Pressure ratio per stage	2.4662	
Specific work (adiabatic, intercooled)	1.4340	kWh/kg
Isothermal work	0.94049	kWh/kg
Isothermal efficiency	65.587	%
Stage discharge temperature	151.32	°C
Shaft power	143.40	kW
Share of the hydrogen lower heating value	4.3038	%

Notes for this case

• Ideal gas, equal pressure ratios, intercooling to T_1: w = N[k/(k − 1)]RT₁(r^((k−1)/k) − 1)/η_s. Hydrogen's compressibility (Z ≈ 1.2–1.5 at 350–700 bar) raises real work by up to about 10 %; motor and cooling losses add more.

Formula and method

$$w = \frac{Nk}{k-1}\frac{RT_1}{\eta_s}\left(r^{(k-1)/k} - 1\right), \quad r = \left(\frac{p_2}{p_1}\right)^{1/N}, \quad w_{iso} = RT_1 \ln\frac{p_2}{p_1}$$

Variables

p_1	Suction pressure	Pa
p_2	Discharge pressure	Pa
T_1	Suction (and intercooled) temperature	K
N	Number of stages	-
η_s	Isentropic efficiency per stage	-
k	Heat capacity ratio (hydrogen 1.41)	-
$\dot{m}$	Hydrogen flow	kg/s
r	Pressure ratio per stage	-
w	Specific work (adiabatic, intercooled)	J/kg
w_{iso}	Isothermal work	J/kg

w_{iso}/w	Isothermal efficiency	-
T_2	Stage discharge temperature	K
P	Shaft power	W
w/LHV	Share of the hydrogen lower heating value	-

Method and standards

Compression work.

Assumptions and limits

- Ideal gas; perfect intercooling; equal stage ratios.

References

Multistage intercooled compression of an ideal gas

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/hydrogen-compression-work

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Reopens the calculator with the inputs of this report.