Multistage Compressor Interstage Pressure and Intercooler Duty

Equal-ratio interstage pressures of a multistage compressor, stage discharge temperatures, shaft power and intercooler duty for an ideal gas.

Method: Ideal-gas staged compression with equal pressure ratios (definitions; Perry's Chemical Engineers' Handbook, 9th ed. (McGraw-Hill, 2019), sec. 10, compressors)

Input parameters

Unit system: SI

Parameter	Value	Unit
Suction pressure (absolute)	1.0132	bar
Final discharge pressure (absolute)	30.000	bar
Number of stages	3.0000	
First-stage suction temperature	30.000	°C
Gas temperature after each intercooler	40.000	°C
Isentropic efficiency per stage	80.000	%
Ratio of specific heats	1.4000	
Molar mass	28.960	kg/kmol
Mass flow	3,600.0	kg/h

Calculated results

Parameter	Value	Unit
Pressure ratio per stage	3.0936	
Discharge pressure of stage 1	3.1346	bar
Discharge temperature of stage 1	174.30	°C
Discharge temperature of later stages	189.06	°C
Total shaft power	444.58	kW
Duty of each intercooler	134.96	kW
Total intercooler duty	284.74	kW

Notes for this case

- Equal ratios minimise power when every stage starts at the same temperature; the first intercooler cools stage-1 gas, the others later-stage gas. No aftercooler included. Pressure drop through intercoolers is neglected.

Formula and method

$$r = \left(\frac{p_2}{p_1}\right)^{1/N}, \quad T_d = T_s + \frac{T_s\left(r^{(\gamma-1)/\gamma} - 1\right)}{\eta_s}, \quad P = \dot{m} c_p \sum (T_d - T_s), \quad Q_{ic} = \dot{m} c_p (T_d - T_{ic})$$

Variables

p_1	Suction pressure (absolute)	Pa
p_2	Final discharge pressure (absolute)	Pa
N	Number of stages	-
T_1	First-stage suction temperature	K
T_{ic}	Gas temperature after each intercooler	K
η_s	Isentropic efficiency per stage	-

γ	Ratio of specific heats	-
M	Molar mass	kg/kmol
$\dot{m}$	Mass flow	kg/s
r	Pressure ratio per stage	-
$p_{i,1}$	Discharge pressure of stage 1	Pa
$T_{d,1}$	Discharge temperature of stage 1	K
$T_{d,n}$	Discharge temperature of later stages	K
P	Total shaft power	W
Q_{ic}	Duty of each intercooler	W
$Q_{ic,total}$	Total intercooler duty	W

Method and standards

Ideal-gas staged compression.

Assumptions and limits

- Ideal gas; constant c_p; equal ratios.

References

• Ideal-gas staged compression with equal pressure ratios (definitions; Perry's Chemical Engineers' Handbook, 9th ed. (McGraw-Hill, 2019), sec. 10, compressors)

Report details

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This calculator online

https://calc.firecad.com/mechanical/compressors/multistage-compressor-interstage

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Reopens the calculator with the inputs of this report.