Heat of Aerobic Fermentation from Oxygen Uptake and Cooling Water

Metabolic heat of an aerobic culture from its oxygen uptake (about 460 kJ per mol O_2), with agitation power, and the cooling-water flow to remove it.

Method: Doran; Bioprocess Engineering Principles; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Oxygen uptake of the whole broth	380.00	kg/h
Heat released per mol O_2 (enter as a positive number)	460.00	kJ/mol
Agitation power to the broth	50.000	kW
Cooling-water temperature rise	5.0000	K

Calculated results

Parameter	Value	Unit
Metabolic heat	1,517.5	kW
Total heat to remove	1,567.5	kW
Cooling-water flow	269.61	t/h

Notes for this case

- Doran quotes about 460 kJ per mol O_2 for aerobic growth on many substrates; Cooney's 0.12 kcal per mmol (about 500 kJ/mol) is also used. Add sparger gas evaporation and heat gains if significant.

Formula and method

$$Q_{met} = \frac{\dot{m}_{O_2}}{M_{O_2}} \Delta H_{O_2}, \quad Q = Q_{met} + P_{ag}, \quad \dot{m}_w = \frac{Q}{c_p \Delta T_w}$$

Variables

$\dot{m}_{O_2}$	Oxygen uptake of the whole broth	kg/s
ΔH_{O_2}	Heat released per mol O_2 (enter as a positive number)	J/mol
M_{O_2}	Molar mass of oxygen, 0.031998 kg/mol	kg/mol
c_p	Specific heat of cooling water, 4186 J/(kg·K)	J/(kg·K)
P_{ag}	Agitation power to the broth	W
ΔT_w	Cooling-water temperature rise	K
Q_{met}	Metabolic heat	W
Q	Total heat to remove	W
$\dot{m}_w$	Cooling-water flow	kg/s

Method and standards

Heat balance.

Assumptions and limits

- Steady state.
- Doran's −460 kJ/mol O_2 is a heat of reaction (negative = released); enter it here as +460 kJ/mol, the heat released.

References

- Doran
- Bioprocess Engineering Principles

- 2nd ed. (Academic Press, 2013)
- ch. 5 (heat of reaction from oxygen consumption, about −460 kJ/mol O_2)
- Cooney
- Wang and Wang (1969)
- Biotechnol. Bioeng. 11: 269

Report details

Report reference	FCC-R4FQ-W10M (the same inputs always give the same reference)
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Release checks	2 reference cases of this calculator, computed independently, are checked on every release

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

This calculator online

https://calc.firecad.com/chemical/bioprocess/aerobic-fermentation-heat

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.