Oxygen Uptake, CO_2 Evolution and Respiratory Quotient from Off-Gas

Oxygen uptake rate, carbon dioxide evolution rate and respiratory quotient of a fermenter from air flow and dry inlet and exhaust O_2 and CO_2 by nitrogen balance.

Method: Inert-gas balance off-gas analysis

Input parameters

Unit system: SI

Parameter	Value	Unit
Inlet air flow (dry, normal)	500.00	Nm³/h
Inlet O_2 (dry)	20.950	%
Inlet CO_2 (dry)	0.040000	%
Exhaust O_2 (dry)	19.500	%
Exhaust CO_2 (dry)	1.2000	%
Broth volume	10.000	m³

Calculated results

Parameter	Value	Unit
Exhaust flow (dry, normal)	498.17	Nm³/h
Oxygen uptake rate	0.33937	kmol/h
CO_2 evolution rate	0.25779	kmol/h
Respiratory quotient	0.75962	
Oxygen uptake per litre of broth per hour	33.937	mmol/L

Notes for this case

• Inert (N_2 + Ar) balance: V_out = V_in(1 − y_O_2,in − y_CO_2,in)/(1 − y_O_2,out − y_CO_2,out); OUR and CER from the O_2 and CO_2 balances at 22.414 L/mol. RQ ≈ 1 on glucose growth, 0.7 on fats, above 1 when ethanol or other reduced products form (overflow metabolism). The last output is the uptake per litre of broth per hour.

Formula and method

$$\dot{V}_{out} = \dot{V}_{in}\frac{1 - y_{O_2,in} - y_{CO_2,in}}{1 - y_{O_2,out} - y_{CO_2,out}}, \quad RQ = \frac{\dot{V}_{out}y_{CO_2,out} - \dot{V}_{in}y_{CO_2,in}}{\dot{V}_{in}y_{O_2,in} - \dot{V}_{out}y_{O_2,out}}$$

Variables

$\dot{V}_{in}$	Inlet air flow (dry, normal)	Nm³/s
$y_{O_2,in}$	Inlet O_2 (dry)	-
$y_{CO_2,in}$	Inlet CO_2 (dry)	-
$y_{O_2,out}$	Exhaust O_2 (dry)	-
$y_{CO_2,out}$	Exhaust CO_2 (dry)	-
V_L	Broth volume	m³
$\dot{V}_{out}$	Exhaust flow (dry, normal)	Nm³/s
OUR	Oxygen uptake rate	mol/s
CER	CO_2 evolution rate	mol/s
RQ	Respiratory quotient	-

OUR/V_L	Oxygen uptake per litre of broth per hour	mol/m³

Method and standards

Off-gas balance.

Assumptions and limits

- Steady state; inert gas unchanged; dry analysis.

References

Inert-gas balance off-gas analysis

Report details

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Release checks	3 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/respiratory-quotient-offgas

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Reopens the calculator with the inputs of this report.