Fed-Batch: Exponential Feed for Constant Growth Rate

Feed rate profile that holds a fed-batch culture at a chosen specific growth rate, with the volume and biomass at a time, from yield and feed concentration.

Method: Doran; Bioprocess Engineering Principles; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Target specific growth rate	0.15000	1/h
Initial biomass (dry cell weight) Dry cell weight per litre of broth.	10.000	g/L
Initial volume	20.000	m³
Biomass yield (dry cells per substrate consumed) kg of dry biomass per kg of the limiting substrate in the feed (for example glucose).	0.50000	kg/kg
Feed substrate concentration	500.00	g/L
Residual substrate held in the vessel	0.10000	g/L
Time from the start of feeding	10.000	h

Calculated results

Parameter	Value	Unit
Initial feed rate	120.02	L/h
Feed rate at t	537.91	L/h
Volume at t	22.786	m³
Biomass in the vessel at t	896.34	kg
Biomass concentration at t	39.337	g/L

Notes for this case

- Maintenance and product formation are neglected; in practice feed is limited by oxygen transfer and cooling as biomass rises.

Formula and method

$$F(t) = \frac{\mu X_0 V_0}{Y_{X/S}(S_f - S)} e^{\mu t}, \quad V(t) = V_0 + \frac{X_0 V_0}{Y_{X/S}(S_f - S)}\left(e^{\mu t} - 1\right), \quad X(t)V(t) = X_0 V_0 e^{\mu t}$$

Variables

μ	Target specific growth rate	1/s
X_0	Initial biomass	kg/m³
V_0	Initial volume	m³
$Y_{X/S}$	Biomass yield	kg/kg
S_f	Feed substrate concentration	kg/m³
S	Residual substrate held in the vessel	kg/m³
t	Time from the start of feeding	s
F_0	Initial feed rate	m³/s
$F(t)$	Feed rate at t	m³/s
$V(t)$	Volume at t	m³
$XV(t)$	Biomass in the vessel at t	kg
$X(t)$	Biomass concentration at t	kg/m³

Method and standards

Substrate balance at constant μ.

Assumptions and limits

- Constant yield; no maintenance.
- X is dry cell weight per litre; Y is dry biomass per kg of the limiting substrate in the feed.
- μ t above 50 is rejected (overflow). A note appears when X(t) passes about 150 g/L or the volume grows more than tenfold, which no real vessel follows.

References

- Doran
- Bioprocess Engineering Principles
- 2nd ed. (Academic Press, 2013)
- ch. 14 (fed-batch culture, exponential feeding)

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/chemical/bioprocess/fed-batch-exponential-feed

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.