Damköhler Number and Conversion in CSTR and PFR

Damköhler number and conversion in an ideal CSTR and plug-flow reactor for first- or second-order kinetics, from rate constant and residence time.

Method: Levenspiel; Chemical Reaction Engineering; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Reaction order	First order	
Rate constant (1/s, or m³/(kmol·s) for second order)	0.002000	
Residence time	30.000	min
Feed concentration (kmol/m³)	1.0000	

Calculated results

Parameter	Value	Unit
Damköhler number	3.6000	
Conversion, CSTR	78.261	%
Conversion, PFR	97.268	%

Notes for this case

- Isothermal, constant density, ideal mixing or plug flow. Da below 0.1 gives under 10 % conversion; above 10, over 90 %.

Formula and method

$$Da = k\tau, \quad X_{CSTR} = \frac{Da}{1+Da}, \quad X_{PFR} = 1 - e^{-Da}$$

$$Da = kC_{A0}\tau, \quad X_{CSTR} = 1 - \frac{\sqrt{1+4Da}-1}{2Da}, \quad X_{PFR} = \frac{Da}{1+Da}$$

Variables

n	Reaction order	-
k	Rate constant (1/s, or m³/(kmol·s) for second order)	-
τ	Residence time	s
C_{A0}	Feed concentration (kmol/m³)	-
Da	Damköhler number	-
X_{CSTR}	Conversion, CSTR	-
X_{PFR}	Conversion, PFR	-

Method and standards

Ideal reactor design equations.

Assumptions and limits

- Constant density; isothermal.
- k and C_A0 are entered as plain numbers in SI: k in 1/s (first order) or m³/(kmol·s) (second order), C_A0 in kmol/m³, whatever unit the residence time is shown in.

References

- Levenspiel
- Chemical Reaction Engineering
- 3rd ed. (Wiley, 1999)
- ch. 5 (ideal reactors)

- Fogler
- ch. 4

Report details

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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/reactors/damkohler-conversion

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.